Commercial RADIO OPERATOR'S QUESTION and ANSWER LICENSE GUIDE

FOR ELEMENT 4

INCLUDES SAMPLE FCC TYPE PRACTICE EXAMS Using MULTIPLE-CHOICE QUESTIONS

PREPARATION FOR RADIOTELEPHONE AND RADIOTELEGRAPH LICENSE EXAMINATIONS

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COMMERCIAL RADIO OPERATOR'S LICENSE GUIDE – ELEMENT 4

by

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PREFACE

The AMECO COMMERCIAL RADIO OPERATOR'S LICENSE GUIDE - ELEMENT 4 is part of a series of guides published by the Ameco Publishing Corp. for the purpose of preparing students for the Federal Communication Commission's commercial radio operator's examinations.

As is the case with the other AMECO guides, this guide includes a sample F. C. C. -type examination. This sample examination provides an added means of preparation for the actual F. C. C. examination, and may serve as an accurate gauge of preparedness. The correct answers to the questions are in the back of the book. The questions duplicate the format of the F. C. C. exam; most of them are of the multiple-choice type, and cover the entire range of material that is covered by the F. C. C. on their examination.

In addition to the other elements, the satisfactory completion of the element 4 examination is necessary for the Radiotelephone 1st class operator's license. The following are the requirements for the various classes of commercial radio operator's licenses and permits issued by the Federal Communications Commission.

Radiotelephone 1st Class Operator's License - Elements 1, 2, 3, 4.
Radiotelephone 2nd Class Operator's License - Elements 1, 2, 3.
Radiotelephone 3rd Class Operator's License - Elements 1, 2.
Restricted Radiotelephone Permit - No written or oral examination.
Radiotelegraph 1st Class Operator's License - Elements 1, 2, 5, 6.
Radiotelegraph 2nd Class Operator's License - Elements 1, 2, 5, 6.
Radiotelegraph 3rd Class Operator's Permit - Elements 1, 2, 5.
Aircraft Radiotelegraph Endorsement on 1st or 2nd Class License - Element 7.
Ship Radar Endorsement on Radiotelegraph or Radiotelephone 1st or 2nd Class License - Element 8.

The F. C. C. examination for element 4 consists of 50 multiple choice questions similar to the examination on page 68. Two percent (2%) credit is allowed for each question answered correctly. Seventy-five percent (75%) is the passing mark for the examination element.

Although this guide covers only element 4 of the Commercial Radio Operator's examination, the Ameco Publishing Corp. has published other guides covering Elements 1, 2 and 3. A license guide covering the requirements for the radio amateur operator examination has also been published.

It is the contention of the author that the student who thoroughly covers the material in this guide will be prepared to pass the F. C. C. commercial radio operator's examination.

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ELEMENT 4

ADVANCED RADIOTELEPHONE

Question 1. A parallel circuit is made up of five branches; three of the branches being pure resistances of 7, 11 and 14 ohms, respectively. The fourth branch has an inductive reactance value of 500 ohms. The fifth branch has a capacitive reactance of 900 ohms. What is the total impedance of this network? If a voltage is impressed across this parallel network, which branch will dissipate the greatest amount of heat?

Answer: The total impedance is 3.276 ohms. The greatest amount of heat will be dissipated by the 7 ohm resistor. We arrive at these answers in the following manner: First, we determine the total resistance of the 3 parallel resistors:

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{7} + \frac{1}{11} + \frac{1}{14}} = 3.276 \text{ ohms}$$

We now have a parallel circuit consisting of a resistance of 3.276 ohms, an inductive reactance of 900 ohms and a capacitive reactance of 500 ohms. The easiest way to find the total impedance of this circuit is to assume a voltage across the circuit and to find the current in each branch by means of Ohm's law. We can then find the total current by means of the formula given below. Once we know the current and the voltage, we can find the impedance by means of Ohm's law. We will assume a voltage of 900 volts across the circuit.

Resistance branch $\quad I_R = \frac{E}{R_T} = \frac{900}{3.276} = 274.7$ amperes

Inductive Reactance branch $\quad I_{X_L} = \frac{E}{X_L} = \frac{900}{500} = 1.8$ amperes

Capacitive Reactance branch $\quad I_{X_C} = \frac{E}{X_c} = \frac{900}{900} = 1$ ampere

$$\text{Total current, } I_T = \sqrt{I_R^2 + (I_{X_L} - I_{X_C})^2} =$$

$$\sqrt{75,460 + (1.8 - 2)^2} = 274.7 \text{ A.}$$

$$Z_T = \frac{E}{I_T} = \frac{900}{274.7} = 3.276 \text{ ohms}$$

The smallest resistance (7 ohms) dissipates most of the heat because it carries the greatest amount of current and the power (heat) is proportional to the square of the current ($P = I^2R$).

Q. 2. What is the reactance of a condenser at the frequency of 1200 kilocycles if its reactance is 300 ohms at 680 kilocycles?

A. The capacitive reactance is 170 ohms at 1200 kc. This is arrived at by setting up the following ratio which is based on the fact that the capacitive reactances are inversely proportional to the frequencies. We shall call X_{C1} the unknown reactance.

$$\frac{X_{C1}}{X_{C2}} = \frac{f2}{f1} \qquad \frac{X_{C1}}{300} = \frac{680}{1200}$$

$$1200\,X_{C1} = 680 \times 300, \quad X_{C1} = 170 \text{ ohms}$$

Q. 3. If the mutual inductance between two coils is 0.1 henry, and the coils have inductances of 0.2 and 0.8 henry, respectively, what is the coefficient of coupling?

A. The coefficient of coupling is .25. We arrive at this by using the standard formula for the coefficient of coupling between 2 coils.

$$K = \frac{M}{\sqrt{L_1 L_2}} = \frac{1}{\sqrt{.2 \times .8}} = \frac{.1}{\sqrt{.16}} = \frac{.1}{.4} = .25$$

where M is the mutual inductance
K is the coefficient of coupling

Q. 4. If, in a given a-c series circuit, the resistance, inductive reactance and capacitive reactance are of equal magnitude of 11 ohms, and the frequency is reduced to 0.411 of its value at resonance, what is the resultant impedance of the circuit at the new frequency?

A. The new impedance is 24.8 ohms. It is arrived at in the following manner:

First we calculate the reactances at the new frequencies. Since X_L is directly proportional to the frequency, the new X_L is equal to $11 \times .411 = 4.52$ ohms. X_c is inversely proportional to the frequency and the new X_c is therefore found by dividing .411 into 11. The new X_c is 26.8 ohms. The resistance doesn't change with frequency.

With the new reactances and the resistance, we can determine the total impedance.

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{11^2 + (4.5-26.8)^2} =$$

$$\sqrt{618.29} = 24.86 \text{ ohms}$$

Q. 5. If an alternating current of 5 amperes flows in a series circuit composed of 12 ohms resistance, 15 ohms inductive reactance and 40 ohms capacitive reactance, what is the voltage across the circuit?

A. The voltage is 138.5 volts. First we determine the impedance of the circuit.

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{12^2 + (15-40)^2} = \sqrt{769} = 27.7 \text{ ohms}$$

We then use ohms law to find the voltage.

$$E = IZ = 5 \times 27.7 = 138.5 \text{ volts.}$$

Q. 6. A series circuit contains resistance, inductive reactance, and capacitive reactance. The resistance is 7 ohms, the inductive reactance is 8 ohms and the capacitive reactance is unknown. What value must this condenser have in order that the total circuit impedance be 13 ohms?

A. The capacitive reactance is 18.96 ohms.

We use the impedance formula and solve for the capacitive reactance, X_C.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}, \quad Z^2 = R^2 + (X_L - X_C)^2, \quad Z^2 - R^2 = (X_L - X_C)^2, \quad \sqrt{Z^2 - R^2} = X_L - X_C, \quad \sqrt{Z^2 - R^2} - X_L = -X_C,$$

$$X_L - \sqrt{Z^2 - R^2} = X_C$$

We then substitute actual values.

$$X_C = 8 - \sqrt{13^2 - 7^2} = 8 - \sqrt{120} = 8 - \pm 10.96$$

This gives us 2 possible solutions; 8 + 10.96 = 18.96 and 8 - 10.96 = -2.96. The latter, a negative value, is obviously wrong. The answer is therefore 18.96 ohms.

Q. 7. What is the total reactance of two inductances connected in series with zero mutual inductance?

A. The total reactance of two inductances connected in series with zero mutual inductance between them is the sum of the reactances.

Q. 8. If an alternating voltage of 115 volts is connected across a parallel circuit made up of a resistance of 30 ohms, an inductive reactance of 17 ohms and a capacitive reactance of 19 ohms, what is the total circuit current drain from the source?

A. The total current is 3.89A.

We first find the current in each branch.

$$I_R = \frac{E}{R} = \frac{115}{30} = 3.83A, \qquad I_L = \frac{E}{X_L} = \frac{115}{17} = 6.76A$$

$$I_C = \frac{E}{X_C} = \frac{115}{19} = 6.05A$$

We then use the formula that was used in answer 1 to find the total current.

$$I_T = \sqrt{I_R{}^2 + (I_{X_L} - I_{X_C})^2} = \sqrt{3.83^2 + (6.76-6.05)^2}$$

$$= \sqrt{14.67 + .5} = \sqrt{15.17} = 3.89A.$$

Q. 9. When two coils, of equal inductance, are connected in series, with unity coefficient of coupling and their fields in phase, what is the total inductance of the two coils?

A. The total inductance is 4 times the inductance of one coil. We arrive at this as follows:

The total inductance of 2 coils in series and in phase is $L_T = L_1 + L_2 + 2M$. - where M, the mutual inductance, is equal to $k\sqrt{L_1L_2}$. We will assume that the inductance of the coils is 1 henry each. We first find the mutual inductance.

$$M = k\sqrt{L_1L_2} = 1\sqrt{1 \times 1} = 1$$

where k is the coefficient of coupling - which is given as 1 in the problem.

We then find the total inductance:

$$L_T = 1 + 1 + 2 = 4 \text{ henries}$$

Thus we see that the total inductance is 4 times the inductance of each coil.

Q. 10. If a power transformer has a primary voltage of 4,400 volts and a secondary voltage of 220 volts, and the transformer has an efficiency of 98 percent, when delivering 23 amperes of secondary current, what is the value of primary current?

A. The primary current is 1.173A.

First we find the secondary power.

$$P_2 = EI = 220 \times 23 = 5060 \text{ watts}$$

Since the transformer is 98% efficient the primary power is

$$\frac{100}{98} \times 5060 = 5163 \text{ watts}$$

We can now find the primary current

$$I = \frac{P}{E} = \frac{5,163}{4,400} = 1.173\text{A}.$$

Q. 11. Three single-phase transformers, each with a ratio of 220 to 2,200 volts, are connected across a 220 volt three-phase line, primaries in delta. If the secondaries are connected in Y, what is the secondary line voltage?

A. The secondary voltage is 3810 volts.

The formula for computing the secondary voltage in a 3 phase delta Y arrangement is $E_s = E_p$ x turns ratio x 1.732 = 3810 volts.

Q. 12. What factors determine the core losses in a transformer?

A. There are 2 types of core losses in a transformer:

a. EDDY CURRENTS. These are wasted currents induced in the iron core of a transformer by the varying magnetic field. These currents take a circular path through the core material. If the core material is solid iron, the resistance in the path of the eddy currents will be low and the eddy currents will be high. These currents serve only to heat up the iron core and therefore represent a power loss. Eddy current losses can be reduced by having the core made up of thin insulated iron sheets called laminations. These laminations limit the eddy currents by increasing the resistance in their path of flow.

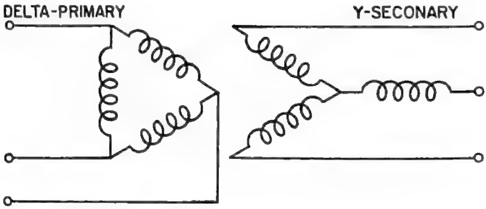
b. HYSTERESIS LOSSES: These represent the energy that is used up in forcing the iron core to reverse the direction of its magnetic field every time the current reverses its direction. Hysteresis losses can be minimized by using cores made of special materials.

Q. 13. What circuit constants determine the "copper" losses of a transformer?

A. Copper losses are caused by the resistance of the wire which makes up the turns of the windings. Current flowing through the resistance of the winding develops an I^2R power loss in the form of wasteful heat. Copper losses can be minimized by using a heavier wire for the windings; a heavier wire will have lower resistance, and therefore a lower I^2R loss.

Q. 14. Draw a schematic wiring diagram of a three-phase transformer with delta connected primary and Y connected secondary.

See page 6 for diagram.



A14 A Delta-Y connected transformer

Q. 15. What factor(s) determine the ratio of impedances which a given transformer can match?

A. This is determined by the turns ratio. The formula linking the turns ratio with the impedances is:

$$\frac{T_p}{T_s} = \sqrt{\frac{Z_p}{Z_s}}$$

Q. 16. If a transformer, having a turns ratio of 10 to 1, works into a load impedance of 2,000 ohms and out of a circuit having an impedance of 15 ohms, what value of resistance may be connected across the load to effect an impedance match?

A. 6000 ohms.

Using the formula of answer 15 and solving for Z_s we can find out what the secondary impedance should be to effect a proper impedance match.

$$\sqrt{\frac{Z_s}{Z_p}} = \frac{T_s}{T_p} \qquad \frac{Z_s}{Z_p} = \left(\frac{T_s}{T_p}\right)^2 \qquad Z_s = \left(\frac{T_s}{T_p}\right)^2 \times Z_p$$

$$Z_s = 10^2 \times 15 = 1500 \text{ ohms}$$

Since the load impedance should be 1500 ohms and since we already have 2000 ohms, we can use the formula for parallel resistors to determine the value of the resistor that should be put in parallel with the 2000 ohms.

$$R_T = \frac{1}{\dfrac{1}{R_1} + \dfrac{1}{R_2}}$$

If we solve for R_2 we arrive at this following formula:

$$R_2 = \frac{1}{\frac{1}{R_T} - \frac{1}{R_1}} = \frac{1}{\frac{1}{1500} - \frac{1}{2000}} = \frac{1}{\frac{4}{6000} - \frac{3}{6000}} = 6000 \text{ ohms}$$

Q. 17. In a class C radio frequency amplifier, what ratio of load impedance to dynamic plate impedance will give the greatest plate efficiency?

A. The maximum plate efficiency depends upon many factors, including plate voltage, signal voltage, bias voltage, etc. Generally speaking, the ratio of load impedance to plate impedance is approximately 4 to 1.

Q. 18. If a lamp, rated at 100 watts and 115 volts, is connected in series with an inductive reactance of 355 ohms and a capacitive reactance of 130 ohms across a voltage of 220 volts, what is the current value through the lamp?

A. The current through the lamp is .843A.

First we find the resistance of the lamp:

$$R_L = \frac{E^2}{P} = \frac{115^2}{100} = 132.25 \text{ ohms}$$

Then we find the total impedance of the circuit.

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(132.25)^2 + (355-130)^2} = \sqrt{68115} =$$

$$260.9 \text{ ohms}$$

The current through the lamp, which is the same as the total current is found by using Ohms law.

$$I_L = \frac{E}{Z} = \frac{220}{260.9} = .843\text{A}.$$

Q. 19. If an a-c series circuit has a resistance of 12 ohms, an inductive reactance of 7 ohms and a capacitive reactance of 7 ohms at the resonant frequency, what will be the total impedance at twice the resonant frequency?

A. The new impedance will be 15.94 ohms.

At twice the frequency, the inductive reactance will be doubled, the capacitance reactance will be halved and the resistance will remain the same. Using these new values, we can calculate the new impedance.

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{12^2 + (14-3.5)^2} = 15.94 \text{ ohms}$$

Q. 20. In a parallel circuit composed of an inductance of 150 microhenrys and a capacitance of 160 micromicrofarads, what is the resonant frequency?

A. The resonant frequency is 1027.7 kc.

It is found by using the formula for the resonant frequency

$$f_r = \frac{10^6}{2\pi\sqrt{LC}} = \frac{1,000,000}{6.28\sqrt{150 \times 160}} = 1027.7 \text{ kc.}$$

where: f_r is the frequency in kilocycles,
C is the capacitance in mmfd.
L is the inductance in microhenries

Q. 21. What value of capacitance must be shunted across a coil having an inductance of 56 microhenrys in order that the circuit resonate at 5,000 kilocycles?

A. The capacitance must be 18.11 mmfd.

We use the formula of answer 20 and solve for C

This gives us:

$$C = \frac{10^{12}}{4\pi^2 f_r^2 L} = \frac{10^{12}}{4 \times (3.14)^2 \times (5000)^2 \times 56} = 18.11 \text{ mmfd.}$$

whereC is in mmfd., f_r is in kc., L is in microhenries and π is 3.14

Q. 22. Why should impedances be matched in speech-input equipment?

A. In speech equipment, impedances should be matched to effect a maximum transfer of power and to minimize distortion.

Q. 23. What are the purposes of H or T pad attenuators?

A. The purpose of H or T pad attenuators is to keep the impedance matching correct while attenuating the signal.

Q. 24. Why are grounded center-tap transformers frequently used to terminate program wire lines?

A. Using center-tap transformers to terminate program wire lines results in a reduction of both noise and stray field pickup.

Q. 25. What is the purpose of a "line pad"?

A. The purpose of a line pad is to introduce attenuation without upsetting the impedance match.

Q. 26. Why are electrostatic shields used between windings in coupling transformers?

A. Their purpose is to reduce capacitive coupling between windings thereby reducing the transfer of unwanted signals and line noises.

Q. 27. Why is it preferable to isolate the direct current from the primary winding of an audio transformer working out of a single vacuum tube?

A. Isolating d-c from the primary winding reduces core saturation and thereby eliminates, somewhat, a cause of distortion.

Q. 28. Why are preamplifiers sometimes used ahead of mixing systems?

A. Preamplifiers are used ahead of mixers to improve the signal-to-noise ratio. Since mixing systems introduce a certain amount of noise, it is important that the signal at this point is large so that it can override the noise.

Q. 29. What is the purpose of a variable attenuator in a speech input system?

A. They are used to adjust the gain of the amplifier and thereby keep the signal at a desired level.

Q. 30. In a low-level amplifier using degenerative feedback, at a nominal mid-frequency, what is the phase relationship between the feedback voltage and the input voltage?

A. Degenerative feedback is a system where a small portion of the output from the plate circuit is fed back to the input circuit 180° out of phase with the input signal.

Q. 31. Under what circumstances will the gain-per-stage be equal to the voltage amplification factor of the vacuum tube employed?

A. The gain of a stage is given by the formula:

$$A = \frac{\mu R_L}{R_p + R_L}$$

where A = gain of stage, "μ" = amplification of tube, R_L = load resistor and R_p = plate resistance.

From the formula it can be seen that the gain of the stage would be equal to "μ" if R_p is zero. Since this is impossible, the gain is never equal to u. However, it can be seen that the higher R_L is, and/or the lower R_p is, the gain of the stage approaches u.

Q. 32. Why is a high-level amplifier, feeding a program transmission line, generally isolated from the line by means of a pad?

A. This is done to isolate the amplifier from the transmission line. It prevents signals in the line from getting back into the amplifier. It also maintains a proper impedance match and prevents the amplifier from overloading the line.

Q. 33. What is the purpose of deliberately introduced degenerative feedback in audio amplifiers?

A. We do this to cancel out some of the distortion and thereby improve fidelity.

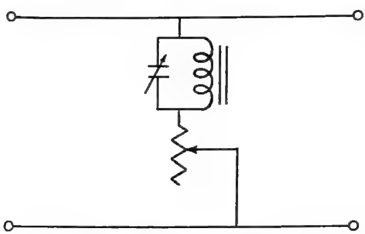
Q. 34. What unit has been adopted by leading program transmission organizations as a volume unit and to what power is this unit equivalent?

A. The unit used is called the "Volume Unit" or VU. This is equivalent to a power of 1 milliwatt at 600 ohms.

Q. 35. What is the purpose of a line equalizer?

A. A line equalizer is used to compensate for the loss of high frequencies in a transmission line. Since a line has distributed capacity, the higher audio frequencies will be shunted. This represents a loss in high frequency response. The line equalizer deliberately reduces the low frequency response to the same extent that the high frequencies are lost. This results in a "flat" overall response.

Q. 36. Draw a diagram of an equalizer circuit most commonly used for equalizing wire-line circuits.



A 36 A line equalizer

Q. 37. What type of microphone employs a coil of wire, attached to a diaphragm, which moves in a magnetic field as the result of the impinging of sound waves?

A. A "dynamic" microphone.

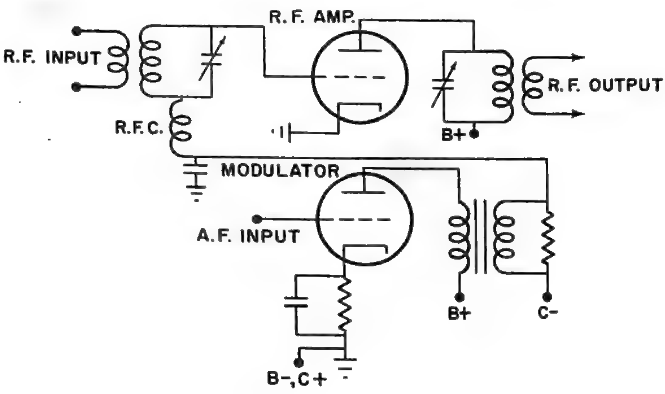
Q. 38. What is the most serious disadvantage of using carbon microphones with high fidelity amplifiers?

A. There are several disadvantages to using a carbon microphone with a high fidelity amplifier. Two of the more serious ones are: 1. The response of a carbon microphone falls off badly at the higher audio frequencies and 2. The carbon granules in the button cause a "hissing" sound.

Q. 39. Why are the diaphragms of certain types of microphones stretched?

A. This is done to raise the resonant frequencies of the diaphragm above the useful audio frequencies so that the diaphragm does not vibrate when certain audio notes strike it.

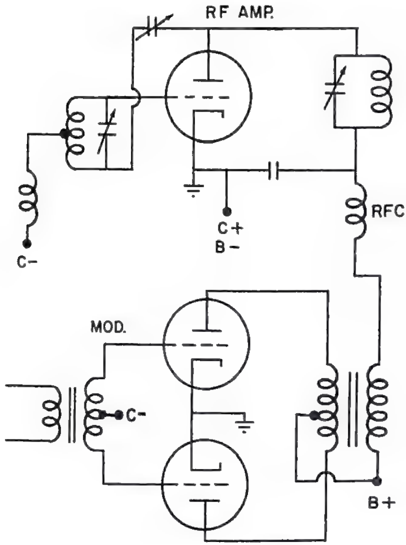
Q. 40. Draw a simple schematic diagram of a grid bias modulation system, including the modulated radio frequency stage.



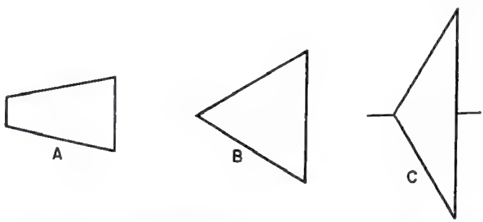
A40 A grid-bias modulation system

Q. 41. Draw a simple schematic diagram of a class B audio high level modulation system, including the modulated radio frequency stage.

Q. 42. Draw a simple sketch of the trapezoidal pattern on a cathode ray oscilloscope screen indicating low percent modulation without distortion.



A41 A Push-pull class B modulator with the r-f stage

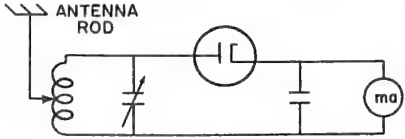


A42 Trapezoidal patterns showing - a) low percent modulation b) 100% modulation c) overmodulation

Q. 43. During 100-percent modulation, what percentage of the average output power is in the side-bands?

A. 33.3% of the total output power.

Q. 44. Draw a schematic diagram of test equipment which may be used to detect carrier shift of a radio telephone transmitter output.



A44 A simple carrier-shift indicator

Q. 45. What are the advantages and disadvantages of class B modulators?

A. Class B modulators have more efficiency than class A or class AB modulators. We can therefore obtain greater power output from a specific type of tube. Some disadvantages of class B modulators are: more distortion than class A, good power supply regulation is required, and a large amount of grid drive is required.

Q. 46. Why is frequency modulation undesirable in the standard broadcast band?

A. Frequency modulation is undesirable in the standard broadcast band because each f-m station requires a large amount of "frequency-space" and there wouldn't be room for enough stations.

Q. 47. What is meant by a "low level" modulation?

A. Low-level modulation refers to the system where a stage preceeding the final stage is modulated.

Q. 48. If a preamplifier, having a 600-ohm output, is connected to a microphone so that the power output is minus 40 db., and assuming the mixer system to have a loss of 10 db., what must be the voltage amplification necessary in the line amplifier in order to feed plus 10 db. into the transmitter line?

A. The line amplifier must have a voltage gain of 1000.

If the output of the preamplifier is - 40 db and if the signal suffers another 10 db loss in the mixer system, then the output of the mixer would be —50 db. In order to bring the signal up to + 10 db, the line amplifier must provide a 60 db gain (50 db to go from —50 db to 0 and 10 db to go from 0 to + 10 db). The voltage amplification equivalent to a 60 db. gain is 1000. This is found by using the following formula and solving for E_{out}/E_{in}.

$$\text{db. gain} = 20 \log \frac{E_{out}}{E_{in}} \qquad 60 = 20 \log \frac{E_{out}}{E_{in}}$$

$$3 = \log \frac{E_{out}}{E_{in}}, \ \log \text{ of } 1000 = 3, \quad \frac{E_{out}}{E_{in}} = 1000$$

Q. 49. If the power output of a modulator is decreased from 1,000 watts to 10 watts, how is the power reduction expressed in decibels?

A. We find this by using the following formula:

$$\text{db.} = 10 \log \frac{P_2}{P_1} = 10 \log \frac{1000}{10} = 10 \log 100 = 10 \times 2 = 20$$

The power loss is therefore 20 db.

Q. 50. In a modulated amplifier, under what circumstances will the plate current vary as read on a d-c meter?

A. Any of the following may cause the plate current in a modulated amplifier to vary

1. overmodulation
2. negative carrier shift
3. positive carrier shift
4. improper neutralization
5. a defective r-f amplifier tube
6. improper bias in r-f amplifier stage
7. insufficient r-f excitation

Q. 51. What could cause downward deflection of the antenna current ammeter of a transmitter when modulation is applied?

A. Downward modulation may be caused by:

a. insufficient excitation of the modulated r-f amplifier
b. insufficient bias of the modulated r-f amplifier
c. excessive loading of the class C modulated r-f amplifier
d. defective output power supply filter
e. poor power supply regulation when a common supply is used

Q. 52. If tests indicate that the positive modulation peaks are greater than the negative peaks in a transmitter employing a class B audio modulator, what steps should be taken to determine the cause?

A. The following checks should be made

1. The tubes should be checked
2. The voltages on the tubes should be checked
3. Neutralization of the modulated amplifier should be checked

4. Audio-frequency excitation to the modulator stage should be checked
5. R-F excitation to final stage should be checked
6. Check tuning of the final tank circuit
7. Check percentage of modulation

Q. 53. In a properly adjusted grid bias modulated radio frequency amplifier, under what circumstances will the plate current vary as read on a d-c meter?

A. Under normal conditions, the plate current will not vary. It will vary if overmodulation is present.

Q. 54. What percentage increase in average output power is obtained under 100 percent sinusoidal modulation as compared with average unmodulated carrier power?

A. The increase would be 50%.

Q. 55. In a class C radio frequency amplifier stage feeding an antenna system, if there is a positive shift in carrier amplitude under modulation conditions, what may be the trouble?

A. Any of the following might cause this:
a. improper neutralization
b. overmodulation
c. final tank circuit not tuned properly
d. insufficient r-f or a-f excitation

Q. 56. Name four causes of distortion in a modulated amplifier stage output?

A. 1. final r-f stage not properly neutralized
2. incorrect r-f drive to final stage
3. overmodulation
4. incorrect voltages on tube
5. defective tube

Q. 57. If you decrease the percentage of modulation from 100 to 50 percent, by what percentage have you decreased the power in the side bands?

A. The power in the sidebands is decreased by 75%. This is easily seen by examining the formula for sideband power:

$$P_s = \frac{m^2}{2} \times P_c$$

where P_s is sideband power, m is % of modulation, and P_c is carrier power.

Note that the sideband power varies directly with the square of the modulation percentage. If we double the modulation percentage, the sideband power becomes 4 x what it was ($2^2 = 4$). If we cut the modulation in half, the sideband power becomes 1/4 of what it was:

$$\left(\frac{1}{2}\right)^2 = \frac{1}{4}.$$

Q. 58. If a certain audio frequency amplifier has an over-all gain of 40 db. and the output is 6 watts, what is the input?

A. We use the db. formula to solve this:

$$\text{db. gain} = 10 \log \frac{P_2}{P_1}, \quad 40 = 10 \log \frac{6}{P_1}, \quad 4 = \log \frac{6}{P_1}$$

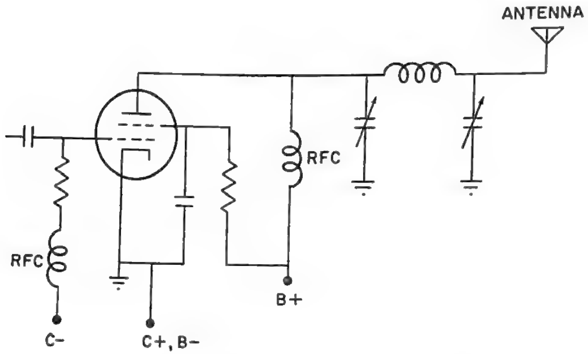
since the log of 10,000 = 4, $P_1 = \dfrac{6}{10,000}$ = .0006 watts or 0.6 milliwatt

Q. 59. If the field intensity of 25 millivolts per meter develops 2.7 volts in a certain antenna, what is its effective height?

A. If the intensity is 25 millivolts per meter, then we must divide this into 2.7 volts to find out how many meters will develope 2.7 volts.

$$\text{Effective height} = 2.7 \div .025 = 108 \text{ meters}$$

Q. 60. Draw a schematic diagram of a final amplifier with capacity coupling to the antenna which will discriminate against the transfer of harmonics.

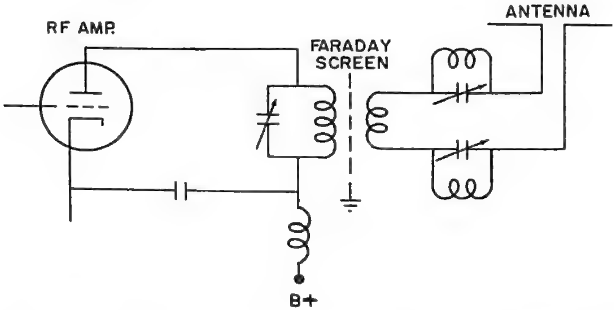


A60 Capacity coupling with harmonic suppression

Q. 61. In what units is the field intensity of a broadcast station normally measured?

A. It is generally measured in microvolts or millivolts per meter.

Q. 62. Draw a simple schematic diagram showing a method of coupling the radio frequency output of the final power amplifier stage of a transmitter to a two-wire transmission line, with a method of suppression of second and third harmonic energy.



A62 Coupling r-f output with a method of harmonic suppression

Q. 63. An antenna is being fed by a properly terminated two-wire transmission line. The current in the line at the input end is 3 amperes. The surge impedance of the line is 500 ohms. How much power is being supplied to the line?

A. 4500 watts. We use the ordinary power formula to find this:

$$P = I^2R = 3^2 \times 500 = 4500 \text{ w.}$$

Q. 64. If the daytime transmission line current of a 10-kilowatt transmitter is 12 amperes, and the transmitter is required to reduce to 5 kilowatts at sunset, what is the new value of transmission line current.

A. First we use the power formula to obtain the resistance of the line:

$$R = \frac{P}{I^2} = \frac{10,000}{12^2} = 70 \text{ ohms}$$

Knowing the resistance and power, we can now find the new current

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{5000}{70}} = \sqrt{71.47} = 8.45\text{A.}$$

Q. 65. If the antenna current of a station is 9.7 amperes for 5 kilowatts, what is the current necessary for a power of 1 kilowatt?

A. This is solved in the same manner as the above problem.

$$R = \frac{P}{I^2} = \frac{5000}{9.7^2} = \frac{5000}{94.1} = 53.1 \text{ ohms}$$

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1000}{53.1}} = \sqrt{18.83} = 4.34\text{A.}$$

Q. 66. What is the antenna current when a transmitter is delivering 900 watts into an antenna having a resistance of 16 ohms?

A. We use the ordinary power formula to solve this problem.

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{900}{16}} = \sqrt{56.25} = 7.5\text{A}$$

Q. 67. If the day input power to a certain broadcast station antenna having a resistance of 20 ohms is 2,000 watts, what would be the night input power if the antenna current were cut in half?

A. 500 watts

First we find out what the day antenna current is:

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{2000}{20}} = 10\text{A.}$$

The night antenna current is therefore 5A.

Now it is a simple matter to find the night input power

$$P = I^2R = 5^2 \times 20 = 500 \text{ watts}$$

Q. 68. The d-c input power to the final amplifier stage is exactly 1,500 volts and 700 milliamperes. The antenna resistance is 8.2 ohms and the antenna current is 9 amperes. What is the plate efficiency of the final amplifier?

A. First we find the input power to the last stage

$$P = EI = 1500 \times .7 = 1050 \text{ watts}$$

We then find the output power

$$P = I^2R = 81 \times 8.2 = 664.2$$

$$\% \text{ Efficiency} = \frac{\text{output power}}{\text{input power}} \times 100 = \frac{664.2}{1050} \times 100 = 63.25\%$$

Q. 69. If the power output of a broadcast station is quadrupled, what effect will this have upon the field intensity at a given point?

A. The field intensity will be doubled. This is because the field intensity is measured in voltage and the voltage varies as the SQUARE ROOT of the power. Therefore, if we quadruple the power, the field intensity or voltage will be doubled ($\sqrt{4} = 2$)

Q. 70. The ammeter connected at the base of a Marconi antenna has a certain reading. If this reading is increased 2.77 times, what is the increase in output power?

A. The output power will be increased by 7.67. Since the formula for power tells us that the power is directly proportional to the square of the current ($P = I^2R$), we arrive at 7.67 by squaring 2.77.

$$(2.77)^2 = 7.67$$

Q. 71. If the power output of a broadcast station has been increased so that the field intensity at a given point is doubled, what increase has taken place in antenna current?

A. The antenna current has been doubled. The field intensity is directly proportional to the antenna current and varies directly with it.

Q. 72. If a transmitter is modulated 100 percent by a sinusoidal tone, what percentage increase in antenna current will occur?

A. An increase of 22.5%. This is arrived at by using the ordinary power formula $I = \sqrt{\frac{P}{r}}$. If, before modulation, we assume a power of 1 watt and an antenna resistance of 1 ohm the antenna current is equal to 1 ampere. If we modulate 100% with a sinusoidal wave, the average power is increased 50% to 1.5 watts. Substituting this in the above formula gives us a current of 1.225 amperes or an increase of 22.5%.

Q. 73. What is the ratio between the currents at the opposite ends of a transmission line, 1/4 wave length long, and terminated in an impedance equal to its surge impedance?

A. The current ratio is 1 to 1. As long as the transmission line is terminated in an impedance equal to its own impedance, there will be no standing waves and the current will be the same all along the line.

Q. 74. The power input to a 72-ohm concentric transmission line is 5,000 watts. What is the r.m.s. voltage between the inner conductor and sheath?

A. The r.m.s. voltage is 600 volts

We find this by using the power formula and solving for voltage

$$E = \sqrt{PR} = \sqrt{5000 \times 72} = 600 \text{ volts}$$

Q. 75. A long transmission line delivers 10 kilowatts into an antenna; at the transmitter end the line current is 5 amperes and at the coupling house it is 4.8 amperes. Assuming the line to be properly terminated and the losses in the coupling system negligible, what is the power lost in the line?

A. The power lost is 875 watts

First we find the impedance at the antenna input

$$R = \frac{P}{I^2} = \frac{10,000}{4.8^2} = 435 \text{ ohms}$$

This is also the line impedance.

Then we can find the power at the transmitter end.

$$P = I^2R = 5^2 \times 435 = 10,875 \text{ watts}$$

The line loss is therefore 10,875 w. - 10,000 w. = 875 watts.

Q. 76. The power input to a 72-ohm concentric line is 5,000 watts. What is the current flowing in it?

A. The current is 8.33A.

This is found by using the power formula

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{5000}{72}} = 8.33\text{A.}$$

Q. 77. What is the primary reason for terminating a transmission line in an impedance equal to the characteristic impedance of the line?

A. Doing this results in:
   a. maximum transfer of power
   b. minimum standing wave ratio
   c. minimum harmonic radiation

Q. 78. If a vertical antenna is 405 feet high and is operated at 1250 kilocycles, what is its physical height, expressed in wave lengths? (One meter equals 3.28 feet.)

A. The physical height is .514 wavelength.

First, change feet into meters

$$\frac{\text{feet}}{3.28} = \text{meters}, \quad \frac{405}{3.28} = 123.47 \text{ meters}$$

Second, change frequency into wavelength

$$\frac{300,000}{\text{frequency in kc.}} = \text{wavelength}, \quad \frac{300,000}{1250} = 240 \text{ meters}$$

If the wavelength of the signal is 240 meters we must divide this into 123.47 to find the physical wavelength of the antenna.

$$\frac{123.47 \text{ meters}}{240 \text{ meters}} = .514 \text{ wavelength}$$

Q. 79. What must be the height of a vertical radiator one-half wave length high if the operating frequency is 1100 kilocycles?

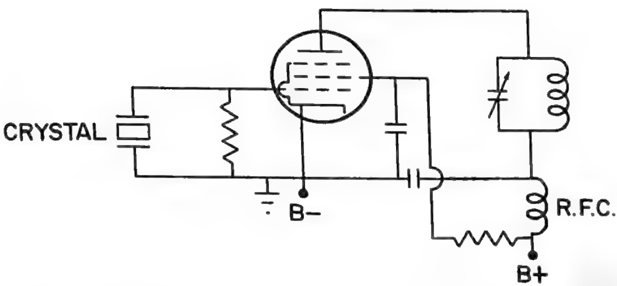
A. The height must be 136.35 meters

This is found by converting kc. to wavelength and dividing by 2

$$\text{wavelength} = \frac{300,000}{f_{kc.}} = \frac{300,000}{1100} \doteqdot 272.7 \text{ meters}$$

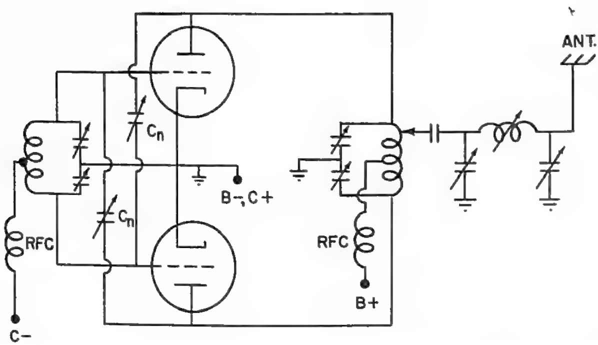
$$\frac{272.7}{2} = 136.35 \text{ meters}$$

Q. 80. Draw a diagram of a crystal oscillator.



A80 A crystal controlled oscillator using a pentode tube

Q. 81. Draw a diagram of a class B push-pull linear amplifier using triode tubes. Include a complete antenna coupling circuit and antenna circuit. Indicate points at which the various voltages will be connected.



A81 Class B push-pull amplifier with an antenna coupling circuit

Q. 82. Draw a diagram of a complete class B modulation system, including the modulated radio frequency amplifier stage. Indicate points where the various voltages will be connected.

A. See answer 41.

Q. 83. A certain transmitter has an output of 100 watts. The efficiency of the final, modulated amplifier stage is 50 percent. Assuming that the modulator has an efficiency of 66 percent, what plate input to the modulator is necessary for 100 percent modulation of this transmitter? Assume that the modulator output is sinusoidal.

A. The input power to the modulator should be 151.5 watts. If the output is 100 watts and the efficiency of the final is 50%, then the input to the final is 200 watts. At 100% modulation the output of the modulator is 1/2 the r-f input. The output of the modulator is therefore 100 watts. We then use the efficiency formula to determine the input modulator power.

$$\text{efficiency} = \frac{P_{output}}{P_{input}}, \quad P_{input} = \frac{P_{output}}{\text{efficiency}} = \frac{100}{.66} = 151.5 \text{ watts}$$

Q. 84. If an oscillatory circuit consists of two identical tubes, the grids connected in push-pull and the plates in parallel, what relationship will hold between the input and output frequencies?

A. The relationship between the input and output frequencies depends primarily on the resonant frequencies of the tuned circuits. The circuit described in the question lends itself well to frequency doubling and if the output circuit is tuned to twice the input circuit

we will have an excellent frequency doubler.

Q. 85. What undersirable effects result from overmodulation of a broadcast transmitter?

A. overmodulation results in:
1. audio distortion
2. interference on adjacent channels
3. the generation of spurious harmonic signals

Q. 86. What do variations in the final amplifier plate current of a transmitter employing low-level modulation usually indicate?

A. Any of the following can cause variations of the final plate current in a transmitter using low level modulation.
1. overmodulation
2. excessive r-f drive
3. plate circuit out of resonance

Q. 87. If, upon tuning the plate circuit of a triode r-f amplifier, the grid current undergoes variations, what defect is indicated?

A. In most instances, this would indicate improper neutralization.

Q. 88. A 50-kilowatt transmitter employs 6 tubes in push-pull parallel in the final class B linear stage, operating with a 50- kilowatt output and an efficiency of 33 percent. Assuming that all of the heat radiation is transferred to the water cooling system, what amount of power must be dissipated from each tube?

A. Each tube must dissipate 16,919 watts.
We first find the total input power by using the efficiency formula:

$$P_{in.} = \frac{P\ out}{eff.} = \frac{50,000}{.33} = 151,515 \text{ watts}$$

We then find the total dissipated power

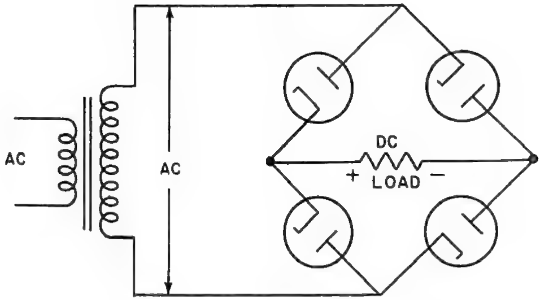
$$151,515 - 50,000 = 101,515 \text{ watts}$$

We divide this amount by 6 ($101,515 \div 6 = 16,919$) to get the power dissipated by each tube.

Q. 89. What is the value of voltage drop across the elements of a mercury-vapor rectifier tube under normal conducting conditions?

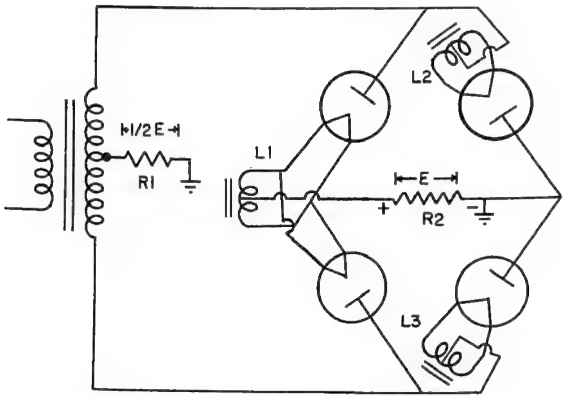
A. It is approximately 15 watts.

Q. 90. Draw a diagram of a bridge rectifier giving full-wave rectification without a center-tapped transformer. Indicate polarity of output terminals.



A90 A full wave bridge type rectifier system

Q. 91. Draw a diagram of a rectifier system supplying two plate voltages, one approximately twice the other and using one high-voltage transformer with a single center-tapped secondary, and such filament supplies as may be necessary.



A91 A rectifier system supplying 2 voltages - one approximately twice the other. Note that this is really a combination of a bridge-type rectifier and a full wave rectifier in one. L1, L2 and L3 represents filament secondaries.

Q. 92. What is meant by "arc back" or "flash back" in a rectifier tube?

A. "Arc back" or "flash back" is the flow of current from the plate of a rectifier tube back to the filament or cathode. This occurs when the reverse voltage ("inverse peak voltage") is high enough to overcome the tubes resistance in the plate to cathode direction. Arc-back can ruin a tube.

Q. 93. What is meant by the "inverse peak voltage" rating of a rectifier tube?

A. The "inverse peak voltage" of a rectifier tube is the maximum peak voltage the tube can take in the reverse direction (plate to cathode) without causing arc-back.

Q. 94. How may a condenser be added to a choke input filter system to increase the full load voltage?

A. If we add a condenser to the input side of the filter, the filter becomes a condenser input type of filter. This will give us a higher output voltage.

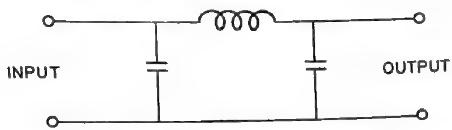
Q. 95. Why is it not advisable to operate a filter reactance in excess of its rated current value?

A. If the current is excessive, it may cause heat damage to the choke. Aside from this, a high current may saturate the core and lower its inductance. This, would affect the filtering.

Q. 96. What is a "low pass" filter? A "high pass" filter?

A. A low pass filter is a circuit that passes frequencies below a certain point and blocks the frequencies above that point. A high pass filter is a circuit that passes frequencies above a certain point and blocks the frequencies below that point.

Q. 97. Draw a diagram of a simple low pass filter.



A97 A low pass filter

Q. 98. If a power supply has a regulation of 11 percent when the output voltage at full load is 240 volts, what is the output voltage at no load?

A. Since the percentage of regulation is the difference between the full load and no load voltage expressed as a percentage of the full load voltage, we can find the no load voltage by taking 11% of 240 Volts and adding it to 240 Volts.

$$(.11 \times 240) + 240 = 266.4 \text{ volts}$$

Q. 99. How is the inverse peak voltage to which the tubes of a full-wave rectifier will be subject, determined from the known secondary voltages of the power transformer? Explain.

A. The peak inverse voltage is equal to the full secondary effective voltage multiplied by 1.414.

Q. 100. If a power supply has an output voltage of 140 volts at no load and the regulation at full load is 15 percent, what is the output voltage at full load?

A. The full load voltage is 121.7 V. We use the formula for percentage regulation and solve for the full load voltage:

$$\% \text{ Regulation} = \frac{E_{\text{No load}} - E_{\text{Full load}}}{E_{\text{Full load}}} \times 100$$

If we multiply both sides of the equation by $E_{\text{FULL LOAD}}$ and algebraicly solve for $E_{\text{FULL LOAD}}$ we arrive at the following formula:

$$E_{\text{Full load}} = \frac{100\ E_{\text{No load}}}{100 + \%\ \text{Reg.}} = \frac{100 \times 140}{100 + 15} = 121.7 \text{ volts}$$

Q. 101. Why is a time delay relay arranged to apply the high voltage to the anodes of mercury vapor rectifier tubes some time after the application of filament voltage?

A. The filament must heat up and vaporize the mercury before plate voltage is applied. Damage to the tube may result if this is not done.

Q. 102. Why is it important to maintain the operating temperature of mercury-vapor tubes within specified limits?

A. This should be done in order to maintain efficiency and long life.

Q. 103. If a frequency doubler stage has an input frequency of 1000 kilocycles, and the plate inductance is 60 microhenries, what value of plate capacitance is necessary for resonance, neglecting

stray capacitances?

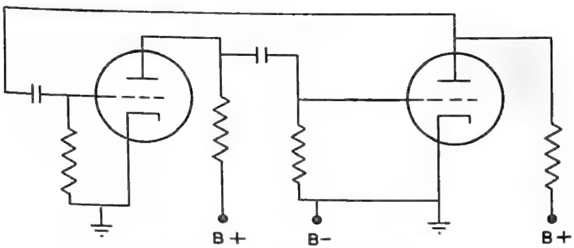
A. The plate capacitance should be 105.6 mmfd. This is found by using the resonance formula and solving for C. Since the stage is a doubler, the output circuit is tuned to 2000 kc.

$$f = \frac{10^6}{2\pi\sqrt{LC}}, \quad \sqrt{LC} = \frac{10^6}{2\pi f}, \quad C = \frac{10^{12}}{4\pi^2 f^2 L}$$

$$\frac{10^{12}}{4 \times 3.14^2 \times (2000)^2 \times 60} = 105.6 \text{ mmfd.}$$

where f is in kc. L is in microhenries and C is in mmfd.

Q. 104. Draw a simple schematic diagram of a multivibrator oscillatory circuit.



A104 A multivibrator circuit

Q. 105. What precautions shouldbe taken to insure that a crystal oscillator will function at one frequency only?

A. The following precautions should be taken:

1. Use a buffer stage between the oscillator stage and the amplifier stages to prevent changes that occur in the amplifiers from affecting the oscillator.
2. Keep the voltages on the oscillator tube's elements constant. A well regulated power supply will do this.
3. Keep the temperature near the crystal constant.
4. Keep the feedback to the crystal to a minimum.
5. Keep all parts of the oscillator circuit mechanically rigid.

Q. 106. What are the advantages of mercury thermostats as compared to bimetallic thermostats?

A. Mercury thermostats make better contacts and are not subject to pitting or corrosion as are bimetallic contacts.

Q. 107. A 600-kilocycle X-cut crystal, calibrated at 50 degrees Centigrade, and having a temperature coefficient of -20 parts per million per degree, will oscillate at what frequency when its temperature is 60 degrees Centigrade?

A. It will oscillate at 599,880 cycles.
The temperature coefficient is 20 cycles per megacycle per degree. It will therefore shift 200 cycles for 10 degrees (50 to 60 degrees). We multiply this by .6 because we are concerned with a .6 Mc. crystal. 200 x .6 = 120 cycles. Since the coefficient is negative, we subtract this from 600,000 cycles to arrive at the new frequency:

600,000 - 120 = 599,880 cycles.

Q. 108. Why are quartz crystals in some cases operated in temperature-controlled ovens?

A. Since the frequency of the crystal varies with changes in temperature, we try to keep the temperature about the crystal constant. This insures good frequency stability.

Q. 109. What is the device called which is used to derive a standard frequency of 10 kilocycles from a standard-frequency oscillator operating on 100 kilocycles?

A. We use a multivibrator type of oscillator for this purpose.

Q. 110. What procedure should be adopted if it is found necessary to replace a tube in a heterodyne frequency meter?

A. The heterodyne frequency meter must then be checked out against a standard generator or calibrator to make certain that it is accurate.

Q. 111. If a frequency of 500 cycles is beat with a frequency of 550 kilocycles, what will be the resultant frequencies?

A. The resultant frequencies will be: 500c., 550kc., 550.5kc, and 549.5kc. Whenever 2 frequencies are "mixed" or "beat" together, we create the sum and difference of the 2 frequencies. We also have the 2 original frequencies.

Q. 112. In what part of a broadcast station system is a "phase monitor" sometimes found? What is the function of this instrument?

A. The "phase monitor" is sometimes found in the antenna system of a broadcast station that has 2 or more antennas. It is necessary to monitor the phase of the currents in the antennas because the directional characteristics of the entire antenna system depend upon

the phase relationship of the currents in the individual antenna elements.

Q. 113. If a broadcast station receives a frequency measurement report indicating that the station frequency was 45 cycles low at a certain time, and the transmitter log for the same time shows the measured frequency to be 5 cycles high, what is the error in the station frequency monitor?

A. The error in the monitor is 50 cycles. The station monitor is 50 cycles "away" from the frequency measurement report (45 cycles to what the frequency should have been, plus the 5 cycles high that the monitor was reading).

Q. 114. If a heterodyne frequency meter, having a straight-line relation between frequency and dial reading, has a dial reading of 31.7 for a frequency of 1390 kilocycles, and a dial reading of 44.5 for a frequency of 1400 kilocycles, what is the frequency of the ninth harmonic of the frequency corresponding to a scale reading of 41.2?

A. 12,576.798 kc.

First we find the frequency that corresponds to 41.2. In order to do this we set up a proportion and solve for x, the difference between 1300 kc. and the frequency corresponding to 41.2.

$$\frac{41.2 - 31.7}{44.5 - 31.7} = \frac{x}{1400 \text{ kc.} - 1390 \text{ kc.}}, \quad \frac{9.5}{12.8} = \frac{x}{10},$$

$$12.8\,x = 95, \quad x = 7.422 \text{ kc.}$$

This is added to 1390 kc. to arrive at the frequency corresponding to a scale reading of 41.2.

$$1390 \text{ kc.} + 7.422 \text{ kc.} = 1397.422 \text{ kc.}$$

We multiply this by 9 to get the ninth harmonic. 1397.422 x 9 = 12,576.798 kc.

Q. 115. What is the reason why certain broadcast station frequency monitors must receive their energy from an unmodulated stage of the transmitter?

A. When we modulate, sideband frequencies and possibly other frequencies are created. This may affect the frequency monitor reading. For best results it is therefore best to monitor an unmodulated stage.

Q. 116. In what part of a broadcast station system are "limiting" devices usually employed? What are their functions?

A. Limiting devices are employed in the speech section of the transmitter. They are used to "limit" or "clip" the peaks of the audio to prevent overmodulation with its consequent distortion and interference.

Q. 117. What are the results of using an audio peak limiter?

A. Audio peak limiters "limit" or cut the peaks of the audio signal thereby preventing distortion and controlling the percentage of modulation.

Q. 118. How is the load on a modulator, which modulates the plate circuit of a class C radio frequency stage, determined?

A. The plate impedance of the r-f amplifier that is modulated is the load on the modulator. The plate impedance is equal to the plate voltage divided by the plate current.

Q. 119. Given a class C amplifier with a plate voltage of 1,000 volts and a plate current of 150 milliamperes which is to be modulated by a class A amplifier with a plate voltage of 2,000 volts, plate current of 200 milliamperes and a plate impedance of 15,000 ohms. What is the proper turns ratio for the coupling transformer?

A. The turns ratio should be 2.12 to 1.

First we find the plate impedance of the r-f amplifier:

$$Z_p = \frac{E}{I} = \frac{1000}{.15} = 6,667 \text{ ohms.}$$

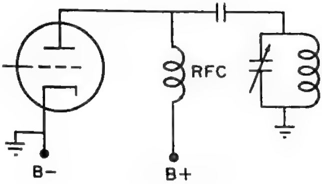
For maximum power transfer with minimum distortion the class A modulator should work into a load of approximately twice its own impedance, or 30,000 ohms. If we were to couple the modulator to the r-f amplifier, we would have a mismatch since we require a 30,000 ohm load but only have a 6,667 ohm load. We must therefore use a transformer with the correct turns ratio to effect a proper impedance match. The following formula is used to find the turns ratio:

$$\text{Turns ratio} = \sqrt{\frac{Z_1}{Z_2}} = \sqrt{\frac{30,000}{6,667}} = 2.12 \text{ or } 2.12 \text{ to } 1$$

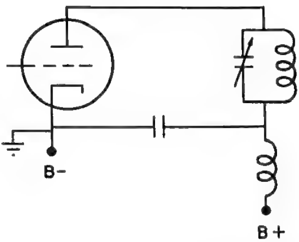
Q. 120. Indicate by a simple diagram, the shunt-fed plate circuit of a radio frequency amplifier.

Q. 121. Indicate, by a simple diagram, the series-fed plate circuit of a radio frequency amplifier.

Q. 122. With respect to the unmodulated values, doubling the ex-



A120 A shunt-fed plate circuit of an r-f amplifier



A121 A series-fed plate circuit of an r-f amplifier

citation voltage of a class B "linear" radio frequency amplifier will result in what increase in r-f power output?

A. If we double the excitation voltage of a linear class B amplifier, we will double the output voltage. This will cause the output power to be quadrupled because the power varies with the square of the voltage.

$$(P = \frac{E^2}{R}).$$

Q. 123. What may be the cause of a decrease in antenna current during modulation of a class B linear r-f amplifier?

A. Downward modulation may be caused by:
  a. insufficient excitation of the modulated r-f amplifier
  b. insufficient bias of the modulated r-f amplifier
  c. excessive loading of the modulated r-f amplifier
  d. defective output power supply filter
  e. poor power supply regulation when a common supply is used

Q. 124. In adjusting the plate tank circuit of a radio frequency amplifier, should minimum or maximum plate current indicate resonance?

A. Minimum plate current indicates resonance.

Q. 125. What is the formula for determining the db. loss or gain in a circuit?

A. With respect to power:

$$\text{db. loss or gain} = 10 \log \frac{P_1}{P_2}$$

With respect to voltage and current:

$$\text{db loss or gain} = 20 \log \frac{E_1 \text{ (or } I_1)}{E_2 \text{ (or } I_2)}$$

Q. 126. What will occur if one tube is removed from a push-pull class A audio frequency amplifier stage.

A. Reduction of power and distortion (especially the second harmonic type) will result.

Q. 127. What is the stage amplification obtained with a single triode operating with the following constants: Plate voltage 250, Plate current 20 ma, Plate impedance 5,000 ohms, Load impedance 10,000 ohms, grid bias 4.5 volts, amplification factor 24?

A. The stage gain would be 16.

The formula for the gain of a triode stage is:

$$\text{gain} = \frac{\mu R_L}{R_P + R_L} = \frac{24 \times 10,000}{5000 + 10,000} = 16$$

Q. 128. Under what circumstances is neutralization of a triode radio frequency amplifier not required?

A. Neutralization is not required when the stage is used as a frequency multiplier or a grounded grid amplifier.

Q. 129. Why is it necessary or advisable to remove the plate voltage from the tube being neutralized?

A. We remove the plate voltage from the stage to be neutralized in order to make the stage inoperative. If the stage is working, r-f energy will get into the plate circuit and it will be difficult to determine the point at which the plate-grid capacitance is neutralized.

Q. 130. Under what conditions may a standard broadcast station be operated at a power lower than specified in the station license? (R. & R. 3.57.)

A. In an emergency, when due to causes beyond control of the licensee, it becomes impossible to operate with full licensed power, the station may be operated with reduced power for a period not to exceed 10 days, provided the Commission and the Engineer in Charge of the radio district in which the station is located shall be notified immediately after the emergency develops and also upon the resumption of licensed power.

Q. 131. When the transmitter of a standard broadcast station is operated at 85 percent modulation, what is the maximum permissible combined audio harmonic output? (S.G.E.P.-A.M. 12.)

A. At 85% modulation, the maximum permissible combined audio harmonic output is 7.5%.

Q. 132. How frequently must the auxiliary transmitter of a standard broadcast station be tested? (R. & R. 3.63.)

A. The auxiliary transmitter shall be tested at least once each week. The tests shall be conducted only between midnight and 9 a.m., local standard time.

Q. 133. For what purpose is an auxiliary transmitter maintained?

A. An auxiliary transmitter is maintained in order to take the place of the main transmitter in the event that the main transmitter fails or is in need of maintenance or repair, provided that the period of repair does not exceed 5 days.

Q. 134. If the plate ammeter in the last stage of a broadcast transmitter burned out, what should be done? (R. & R. 3.58.)

A. In the event that the plate ammeter becomes defective when no substitute which conforms with the required specifications is available, the station may be operated without the defective instrument pending its repair or replacement for a period not in excess of 60 days without further authority of the Commission: Provided, That:

1. Appropriate entries shall be made in the operating log of the station showing the date and time the meter was removed from and restored to service.
2. The Engineer in Charge of the radio district in which the station is located shall be notified both immediately after the instrument is found to be defective and immediately after the repaired or replacement instrument has been installed and is functioning properly.
3. If conditions beyond the control of the licensee prevent the restoration of the meter to service within the above allowed period, an informal request may be filed with the Engineer in Charge of the radio district in which the station is located for such additional time as may be required to complete repairs of the defective instrument.

Q. 135. The currents in the elements of a directive broadcast antenna must be held to what percentage of their licensed value? (R. & R. 3.57.)

A. The ratio of the antenna currents in the elements of the system shall be maintained to within 5 percent of that specified in the license.

Q. 136. What are the permissible tolerances of power of a standard broadcast station? (R. & R. 3.57.)

A. The permissible tolerances are 5 percent above and 10% below the licensed power.

Q. 137. What are meant by "equipment", "program" and "service" tests where these are mentioned in the Rules and Regulations of the Commission? (R. & R. 3.167, 3.168, 7.64.)

A. Equipment tests are tests conducted during the process of construction of a broadcast station. These tests are conducted for the purpose of making those measurements or adjustments necessary to comply with the terms of the construction permit, the technical provisions of the application, and the applicable engineering standards. The F.C.C. and the Engineer in Charge of the radio district must be notified of these tests.

Program tests are conducted after the completion of construction of a standard broadcast station. The Engineer in Charge must be notified 10 days prior to the date on which program tests are to be conducted.

Service test: When equipment tests have been completed, and after application for station license or modification thereof has been filed with the Commission showing the transmitting equipment and associated apparatus to be in satisfactory operating condition, the permittee is authorized to conduct service tests in exact accordance with the terms of the construction permit for a period not to exceed 30 days: Provided, That the Commission's engineer in charge of the radio district in which the station is located is notified two days in advance of the beginning of such tests and that the permittee is not notified by the Commission to cancel, suspend, or change the date (s) for such tests.

Q. 138. At broadcast stations using the direct method of computing output power, at what point in the antenna system must the antenna current be measured? (R. & R. 3.14, 3.54.)

A. The antenna current is measured at the point of maximum current.

Q. 139. For what purpose may a standard broadcast station, licensed to operate daytime or specified hours, operate during the experimental period without specific authorization? (R. & R. 3.73.)

A. A station may operate during the experimental period in order to make frequency measurements or tests to determine interference. See answer 145.

Q. 140. What is the last audio frequency amplifier stage which modulates the radio frequency stage termed? (R. & R. 3.14.)

A. The modulator stage.

Q. 141. How frequently must a remote reading ammeter be checked against a regular antenna ammeter? (S.G.E.P.-A.M. 13.)

A. At least once a week.

Q. 142. What factors enter into the determination of power of a broadcast station which employs the indirect method of measurement?

A. Using the indirect measurement method we use the following formula to determine the operating power of a broadcast station:

$$\text{Operating Power} = E_p \times I_p \times F$$

where: E_p is the plate voltage,
I_p is the total plate current
F is a factor that is found in FCC tables. F depends upon the type of modulation and power used.

Q. 143. What is the power that is actually transmitted by a standard broadcast station termed?

A. The power that is supplied to the antenna is called the "operating power".

Q. 144. Are the "antenna current," "plate current," etc., as used in the Rules and Regulations of the Commission with reference to radio telephone transmitters, modulated or unmodulated values? (R. & R. 3.14.)

A. These are "unmodulated" values.

Q. 145. With reference to broadcast stations, what is meant by the "experimental period"? (R. & R. 3.10.)

A. The term "experimental period" means that time between 12 midnight and local sunrise. This period may be used for experimental purposes in testing and maintaining apparatus by the licensee of any standard broadcast station on its assigned frequency and with its authorized power, provided no interference is caused to other stations maintaining a regular operating schedule within such period. No station licensed for "daytime" or "specified hours" of operation may broadcast any regular or scheduled program during this period.

Q. 146. What percentage of modulation capability is required of

a standard broadcast station ? (S. G. E. P. -A. M. 12.)

A. At least 85 to 95 percent modulation is required.

Q. 147. Define the maximum rated carrier power of a broadcast station transmitter. (R. & R. 3.14.)

A. "Maximum rated carrier power" is the maximum power at which the transmitter can be operated satisfactorily and is determined by the design of the transmitter and the type and number of vacuum tubes used in the last radio stage.

Q. 148. Define the plate input power of a broadcast station transmitter. (R. & R. 3.14.)

A. "Plate input power" means the product of the direct plate voltage applied to the tubes in the last radio stage and the total direct current flowing to the plates of these tubes, measured without modulation.

Q. 149. Define high level and low level modulation. (R. & R 3.14.)

A. "High level modulation" is modulation produced in the plate circuit of the last radio stage of the system. "Low level modulation" is modulation produced in an earlier stage than the final.

Q. 150. What is the frequency tolerance for a standard broadcast station? (R. & R. 3.59.)

A. The operating frequency of each station shall be maintained within 20 cycles of the assigned frequency.

Q. 151. What is the frequency tolerance allowed an International Broadcast station? (R. & R. 3.767.)

A. The operating frequencies of international broadcast station transmitters shall be maintained within 0.005% of the assigned frequencies.

Q. 152. What is the required full scale accuracy of the ammeters and voltmeters associated with the final radio stage of a broadcast transmitter? (S. G. E. P. -A. M. 13.)

A. Accuracy shall be within 2% of the full scale reading.

Q. 153. If a broadcast transmitter employs seven tubes of a particular type, how many spare tubes of the same type are required to be kept on hand in accordance with F. C. C. regulations? (S. G. E. P. -A. M. 12.)

A. 3 spare tubes would be required. 1 spare is required for between 1 and 2 tubes of a particular type; 2 spares are required for between 3 and 5 tubes of a particular type; 3 spares are required for between 6 and 8 tubes of a particular type; and 4 spares are required for 9 or more tubes of a particular type.

Q. 154. Describe the various methods by which a standard broadcast station may compute its operating power, and state the conditions under which each method may be employed. (R. & R. 3.51.)

A. In general, the operating power of each station shall be determined by DIRECT MEASUREMENT of the antenna power. This is done by multiplying the square of the antenna current by the antenna resistance at the point where the current is measured.

A second method of determining operating power is the INDIRECT MEASUREMENT method. This is given in answer 142 and is to be used only in case of emergency where the licensed antenna system has been damaged by causes beyond the control of the licensee, or pending completion of authorized changes in the antenna system.

Q. 155. What portion of the scale of an antenna ammeter having a square law scale is considered as having acceptable accuracy for use at a broadcast station ? (S.G.E.P.-A.M. 13.)

A. No scale division above one-third full scale reading (in amperes) shall be greater than one-thirtieth of the full scale reading. (Example: An ammeter having full scale reading of 6 amperes is acceptable for reading currents from 2 to 6 amperes, provided no scale division between 2 and 6 amperes is greater than one-thirtieth of 6 amperes, 0.2 ampere.)

Q. 156. Define: Amplifier gain, percentage deviation, stage amplification, and percentage of modulation. Explain how each is determined.

A. Amplifier gain refers to the amount of amplification, or step-up or multiplication in terms of voltage or power that an amplifier gives to a signal. Amplifier gain is usually expressed in a unit called decibels and can be measured by instruments.

Percentage deviation refers to the amount of frequency variation of a signal from its normal, expressed in a percentage. This can be measured by instruments.

Stage amplification refers to the gain, or step-up, or multiplication that a tube and its associated parts (a stage) gives to a signal. Stage amplification can be measured with instruments.

"Percentage modulation" with respect to an amplitude modulated wave means the ratio of half the difference between the maxi-

mum and minimum amplitudes of the amplitude modulated wave to the average amplitude expressed in percentage.

"Percentage modulation" as applied to frequency modulation means the ratio of the actual frequency swing to the frequency swing defined as 100 percent modulation, expressed in percentage. For f-m broadcast stations a frequency swing of ±75 kilocycles is defined as 100 percent modulation.

Q. 157. Define an auxiliary broadcast transmitter and state the conditions under which it may be used. (R. & R. 3.13, 3.63.)

A. The term "auxiliary transmitter" means a transmitter maintained only for transmitting the regular programs of a station in case of failure of the main transmitter. It may also be used during maintenance or modification work on the main transmitter necessitating discontinuance of its operation for a period not to exceed five days.

Q. 158. What is the purpose of using a frequency standard or service independent of the transmitter frequency monitor or control?

A. A frequency standard is used to check the accuracy of the transmitter frequency monitor which in turn checks or monitors the transmitter's frequency.

Q. 159. Discuss the characteristics of a modulated class C amplifier.

A. The main characteristics of a tube operating as a class C amplifier are:

1. the grid is biased anywhere from 1 and 1/2 to 4 times cut-off.
2. high plate circuit efficiency.
3. large amount of distortion of the signal.
4. grid current flows.
5. plate current flows for less than 180° of the time.

Q. 160. What is the purpose of neutralizing a radio-frequency amplifier stage?

A. An r-f amplifier stage is neutralized in order to prevent it from oscillating. It oscillates because of the feedback from the plate circuit to the grid circuit through plate-grid capacitance of the tube. All triode r-f amplifier stages and some high frequency tetrode and pentode amplifier stages have to be neutralized.

Q. 161. When the authorized nighttime power of a standard broadcast station is different from the daytime power and the operating power is determined by the "indirect" method, which of the efficiency factors established by FCC rules is used? (R. & R. 3.52, 3.53.)

A. We use the efficiency factor given for the maximum rated carrier power of the transmitter.

Q. 162. Describe the technique used in frequency measurements employing a 100-kilocycle oscillator, a 10-kilocycle multivibrator, a heterodyne frequency meter of known accuracy, a suitable receiver, and standard frequency transmission.

A. The easiest way to measure frequency would be as follows:

Using a suitable calibrated receiver, tune to the unknown frequency. We then tune the heterodyne frequency meter until we hear a beat note on the receiver. We zero beat the two signals and the reading of the frequency meter gives us the unknown frequency. The heterodyne frequency meter can be calibrated to a high degree of accuracy by comparison with standard frequency transmissions.

Care must be used in heterodyne frequency measurement because in most cases harmonics are used. It is important to know which harmonic is being put out by the heterodyne frequency meter.

The calibration of the heterodyne frequency meter may also be checked by comparing it with a 100 kc. oscillator. The 100 kc. oscillator is usually crystal controlled and therefore quite accurate. It puts out harmonics every 100 kc. and these are compared with the heterodyne frequency meter. The 100 kc. oscillator can also be used to synchronize a 10 kc. multivibrator which will provide check points every 10 kc.

Q. 163. What is the power specified in the instrument of authorization for a standard broadcast station called?

A. "Authorized power" or "licensed power".

Q. 164. What is the effect of 10,000 cycle modulation of a standard broadcast station on adjacent channel reception?

A. This will cause interference to the adjacent channel since sidebands will be produced that will fall in the adjacent channel.

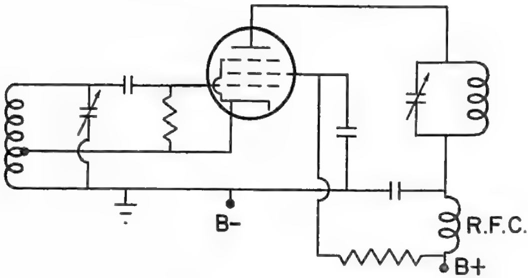
Q. 165. What system of connections for a three-phase, three-transformer bank will provide maximum secondary voltage?

A. The delta-primary, Y-secondary system will provide maximum secondary voltage. Diagram A14 illustrates this arrangement.

Q. 166. Draw a diagram and describe the electrical characteristics of an electron-coupled oscillator circuit.

In an electron-coupled type of oscillator:

a. there is good frequency stability with a large output
b. high efficiency is maintained



A166 An electron coupled oscillator

c. a tetrode or pentode is used as a combination oscillator-amplifier

Q. 167. In frequency measurements using the heterodyne "zero beat" method, what is the best ratio of signal e-m-f to calibrated heterodyne oscillator e-m-f?

A. A 1 to 1 ratio is desirable.

Q. 168. What is meant by the "Q" of a radio-frequency inductance coil?

A. The Q of a coil is the "figure of merit" or "gain" of the coil. A tuned circuit containing a high Q coil will provide more gain and selectivity to the signal. The formula for the Q of a coil is:

$$Q = \frac{X_L}{R}$$

where X_L is the inductive reactance of the coil and R is the total a-c and d-c resistance of the coil.

Q. 169. What effect does a loading resistance have on a tuned radio-frequency circuit?

A. A loading resistance will reduce the gain or Q of the tuned circuit at its resonant frequency. This in turn will reduce the selectivity of the tuned circuit and broaden its response curve.

Q. 170. What is meant by the "time constant" of a resistance-capacitance circuit?

A. The time- constant of a resistance-capacity circuit is the time in seconds that it takes the condenser to charge up to 63.2% of the applied voltage. The formula for determining the time-constant is:

$$TC = R \times C$$

where TC is time-constant in seconds, R is resistance in ohms and C is capacity in farads.

Q. 171. A potential of 110 volts is applied to a series circuit containing an inductive reactance of 25 ohms, a capacitive reactance of 10 ohms and a resistance of 15 ohms. What is the phase relationship between the applied voltage and the current flowing in this circuit?

A. The current lags the applied voltage by 45 degrees. This is found by using the following formula:

$$\text{Tangent of phase angle} = \frac{X}{R}$$

where R is resistance and X is the reactance in the circuit. Since X_L and X_c oppose each other, we subtract one from the other to find the resultant reactance. Therefore:

$$\text{Tan. of phase angle} = \frac{15}{15} = 1$$

The trigonometry tables tell us that the tangent of 45° = 1. The phase angle is therefore 45°. Since X_L predominates over X_c, the reactance is inductive and the current lags the voltage.

Q. 172. What does the term "power factor" mean in reference to electrical power circuits?

A. Power factor is the ratio of the true power as measured by a wattmeter to the apparent power as computed by multiplying the voltmeter reading and the ammeter reading. In an a-c circuit, the true power is always less than the apparent power. This is so because the voltage and current are out of phase, and there are times when current is being sent back into the source.

Q. 173. What is the predominant ripple frequency in the output of a single-phase full-wave rectifier when the primary source of power is 110 volts at 60 cycles?

A. 120 cycles.

Q. 174. When mercury-vapor tubes are connected in parallel in a rectifier system, why are small resistors sometimes placed in series with the plate leads of the tubes?

A. Small resistors in series with the plate of each tube tend to equalize the voltage and hence ionization of the tubes. Without the resistors, one tube may ionize first and take almost the entire current.

Q. 175. A rectifier-filter power supply is designed to furnish 500 volts at 60 milliamperes to one circuit and 400 volts at 40 milliamperes to another circuit. The bleeder current in the voltage divider is to be 15 milliamperes. What value of resistance should be placed between the 500- and 400-volt taps of the voltage divider.

A. The resistance between the 400 volt tap and the 500 volt tap should be 1818 ohms.

By examining figure A175 we see that the resistance between the 400 volt tap and the 500 volt tap must carry the 15 ma. of the bleeder resistor plus the 40 ma. coming from the 400 volt load. Using ohm's law we can find the amount of resistance that will satisfy these conditions.

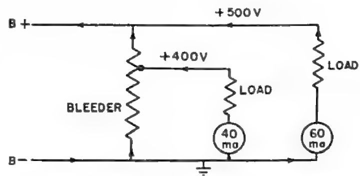


Fig. A175 A bleeder with 400 volt and 500 volt taps

$$R = \frac{E}{I} = \frac{100}{.055} = 1818 \text{ ohms}$$

Q. 176. What is the approximate speed of a 220-volt, 60-cycle, 4-pole, 3-phase induction motor?

A. The approximate speed is 1800 r.p.m. This is found by using the following formula for the approximate synchronous speed. (The actual speed is slightly less.)

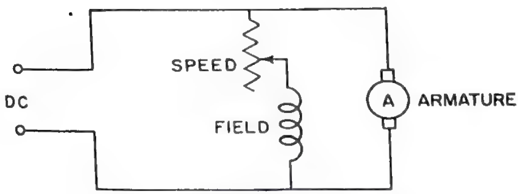
$$\text{Syn. speed} = \frac{120 \times f}{N} = \frac{120 \times 60}{4} = 1800 \text{ r.p.m.}$$

where f is equal to the line frequency and N is equal to the number of poles.

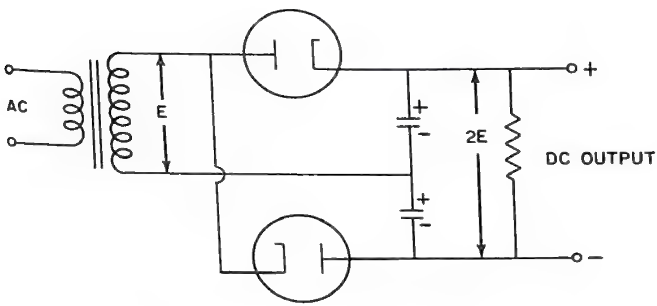
Q. 177. Draw a diagram of a shunt wound d-c motor.

Q. 178. Draw a diagram of a voltage doubling power supply using two half wave rectifiers.

Q.• 179. Why is degenerative feedback sometimes used in an audio amplifier?



A177 A shunt-wound d-c motor



A178 A voltage doubler power supply

A. Degenerative feedback is used to reduce distortion in an audio amplifier. See answer 33.

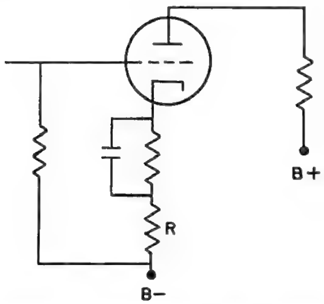
Q. 180. What determines the fundamental operating frequency range of a multivibrator oscillator?

A. The fundamental operating frequency of a multivibrator is determined mainly by the condensers and resistors in the grid circuits of the tubes.

Q. 181. Draw a diagram of an audio amplifier with inverse feedback.

Q. 182. What is the meaning of "mutual conductance," and "amplification factor" in reference to vacuum tubes?

A. The MUTUAL CONDUCTANCE of a tube is the figure of merit of the tube. It tells us how much of a plate current variation we can



A 181 An audio amplifier stage with inverse feedback

get for a certain amount of grid voltage variation. Transconductance is defined as the ratio of a small change in plate current to the change in grid voltage that produced it. The formula for transconductance is:

$$\text{Transconductance } (G_m) = \frac{\Delta I_p}{\Delta E_g}$$

where: ΔI_p is a small change in plate current

ΔE_g is the small change in grid voltage that caused ΔI_p.

G_m is the symbol for transconductance

The basic unit of the transconductance of a tube is the MHO.

The Amplification Factor of a tube is the maximum voltage amplification which can be expected from the tube. It is a theoretical value never reached in actual circuit use. Stated mathematically, it is the ratio of the change in plate voltage to the change in grid voltage that produces the same change in plate current. For example, let us assume that a certain tube is operating with a plate voltage of 250 volts, a grid voltage of -10 volts and a plate current of 18 ma. Let us assume that if we should change the plate voltage to 280 volts and leave the grid voltage constant, the plate current would go up to 23 ma. This means that a plate voltage change of 30 volts results in a plate current change of 5 ma. Suppose that a grid voltage change from -10 volts to -13 volts returns the plate current from 23 ma. back to 18 ma. We can say that a grid voltage change of 3 volts has the

same effect on the plate current as a plate voltage change of 30 volts. The amplification factor would therefore be the plate voltage change (30 volts) divided by the grid voltage change (3 volts) or 10.

The amplification factor is commonly designated by the Greek letter μ. The formula for the μ, or mu, of a tube is:

$$\text{Amplification factor } (\mu) = \frac{\Delta E_p}{\Delta E_g}$$

The terms ΔE_p and ΔE_g mean a small change in plate voltage and a small change in grid voltage respectively.

Q. 183. What is the purpose of a screen grid in a vacuum tube?

A. The screen grid makes the plate current independent of the plate voltage, thus allowing for greater amplification than a triode. It also reduces the capacity between the plate and control grid. This makes it unnecessary to neutralize the tetrode when used as an amplifier.

Q. 184. What is meant by secondary emission in a vacuum tube?

A. Secondary emission is the emission of electrons from a surface that is being bombarded with other electrons. In the case of vacuum tubes, it is the electrons that are dislodged from the plate because the plate is being hit with electrons from the cathode.

Q. 185. Why are grounded grid amplifiers sometimes used at very high frequencies?

A. Grounded grid amplifiers are very stable and will not require neutralization. The grounded grid circuit reduces the output to input (plate to cathode) capacity and makes oscillation almost impossible.

Q. 186. What material is used in shields to prevent stray magnetic fields in the vicinity of radio-frequency circuits?

A. Low resistance conductors such as aluminum and copper are used.

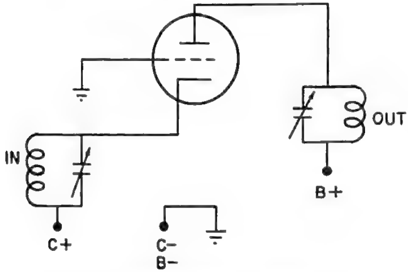
Q. 187. For maximum stability, should the tuned circuit of a crystal oscillator be tuned to the exact crystal frequency.

A. No. At the exact dip point, the crystal controlled oscillator is critical and slight changes may throw it out of oscillation. If we reduce the capacity slightly from the exact dip point, it will be difficult for changes to cause the oscillator to stop oscillating.

Q. 188. What is the principal advantage of a class C amplifier?

A. The principle advantage of a class C amplifier is its high plate efficiency. It may be in the order of 60 to 90%.

Q. 189. Draw a diagram of a grounded grid amplifier.



A189 A grounded-grid amplifier

Q. 190. A current-squared meter has a scale divided into 50 equal divisions. When 45 milliamperes flow through the meter the deflection is 45 divisions. What is the current flowing through the meter when the scale deflection is 25 divisions?

A. The current will be 33.5 ma.

Since the deflection of the meter is proportional to the square of the current, we can set up a proportion and solve for the unknown current.

$$\frac{\text{Def.}_1}{\text{Def.}_2} = \frac{I_1^2}{I_2^2}, \quad \frac{25}{45} = \frac{I_1^2}{45^2}, \quad I^2 \times 45 = 25 \times 2025,$$

$$I = \sqrt{\frac{50625}{45}} = 33.5 \text{ ma.}$$

Q. 191. What is the ohms per volt of a voltmeter constructed of a 0-1 d-c milliammeter and a suitable resistor which makes the full scale reading of the meter 500 volts?

A. The sensitivity of a voltmeter, stated in "ohms per volt" is found by dividing the full scale current into one. The sensitivity of a voltmeter using an 0-1 ma. movement is:

$$\frac{1}{.001} = 1,000 \text{ ohms per volt}$$

Q. 192. What is the power output of an audio amplifier if the volt-

age across the load resistance of 500 ohms is 40 volts?

A. We find this by using the basic power formula.

$$P = \frac{E^2}{R} = \frac{40^2}{500} = \frac{1600}{500} = 3.2 \text{ watts}$$

Q. 193. What type of meter is suitable for measuring peak a-c voltage?

A. There are several ways of doing this:

1. Use an ordinary meter and multiply the reading by 1.414.
2. Use a peak-reading type of vacuum tube voltmeter
3. Use a calibrated oscilloscope

Q. 194. What type of meter is suitable for measuring the A.V.C. voltage in a standard broadcast receiver?

A. A sensitive voltmeter of at least 20,000 ohms per volt or a vacuum tube voltmeter should be used.

Q. 195. What type of meter is suitable for measuring radio-frequency currents?

A. A thermocouple type of meter or hot wire type of meter should be used.

Q. 196. What type of voltmeter absorbs no power from the circuit under test?

A. A vacuum tube voltmeter.

Q. 197. What type of voltmeter is appropriate to measure peak a-c voltages?

A. See answer 193.

Q. 198. If the spacing of the conductors in a two-wire radio-frequency transmission line is doubled, what change takes place in the surge impedance of the line?

A. The surge impedance is increased by 25%. If we examine the formula for the surge impedance of a two-wire transmission line, we will see that an increase in the distance between the conductors causes an increase in the surge impedance. If we compare the equation using "a" with the equation using "2a" and solve the problems with actual values, we would find that the increase in surge impedance is 25%.

$$Z_S = 276 \log \frac{a}{b}$$

where a is the distance between conductors and b is the diameter of the conductors.

Q. 199. If the conductors in a two-wire radio-frequency transmission line are replaced by larger conductors, how is the surge impedance affected, assuming no change in the center-to-center spacing of the conductor?

A. The surge impedance is reduced. This can be seen by an examination of the formula in the above answer.

Q. 200. Why is an inert gas sometimes placed within concentric radio-frequency transmission cables?

A. This prevents moisture from getting into the cable and thereby reduces losses and the possibility of arcing.

Q. 201. What is the direction of maximum radiation from two vertical antennas spaced 180 degrees and having equal currents in phase?

A. The field pattern will be bi-directional (figure 8) in a direction that is perpendicular to a line joining the 2 antennas.

Q. 202. Explain the properties of a quarter-wave section of a radio-frequency transmission line.

A. A quarter wave section of an r-f transmission line exhibits different properties depending upon how it is terminated. If it is terminated in an open circuit, it acts as a series resonant circuit and presents a low impedance at the other end. If it is terminated in a short circuit, it acts as a parallel resonant circuit and presents a high impedance at the other end. Thus we see that a quarter wave section of a transmission line "inverts" the impedance.

Quarter wave sections of transmission lines are commonly used as impedance matching devices.

Q. 203. How does the field strength of a standard broadcast station vary with distance from the antenna?

A. The field strength of a standard broadcast station is inversely proportional to the distance from the transmitting antenna.

Q. 204. What pattern on a cathode-ray oscilloscope indicates overmodulation of a standard broadcast station?

A. See answer 42.

Q. 205. What is a Doherty amplifier?

A. A Doherty amplifier is a high efficiency linear r-f amplifier. It uses 2 tubes and its efficiency is approximately 65% compared to

33% for conventional class B linear amplifiers. In the Doherty amplifier, each tube amplifies a different portion of the modulated carrier. This results in high efficiency.

Q. 206. Why do some standard broadcast stations use top-loaded antennas?

A. An antenna is top-loaded in order to cut down its physical height and maintain the proper electrical height. Top-loading is accomplished by connecting several conductors to the top of the antenna. By top-loading an antenna, we also increase the radiation efficiency of the antenna.

Q. 207. How may a standard broadcast antenna ammeter be protected from lightning?

A. We can protect the ammeter from lightning by placing a large shorting switch across the ammeter. The ammeter should be shorted out with this switch during electrical storms.

Q. 208. What is the ratio of unmodulated carrier power to instantaneous peak power, at 100 percent modulation at a standard broadcast station?

A. At 100% modulation, the instantaneous peak power is 4 times as great as the unmodulated carrier power.

Q. 209. What effect do broken ground conductors have on a standard broadcast antenna?

A. Broken ground conductors reduce the intensity of the signal being radiated from the antenna. A good vertical antenna system has many conductors burried in the earth to form a good ground. Naturally, if any of these ground conductors are broken, the ground will not be as good, electrically, as it was and the antenna radiation efficiency will be reduced.

Q. 210. What may cause unsymmetrical modulation of a standard broadcast transmitter?

A. Any of the following may cause unsymmetrical modulation of a standard broadcast transmitter:

a. insufficient excitation to the grid of the modulated r-f amplifier
b. poor power supply voltage regulation
c. impedance mismatch between the load and the modulated r-f amplifier
d. audio distortion

e. defective tubes
f. tank circuits out of tune

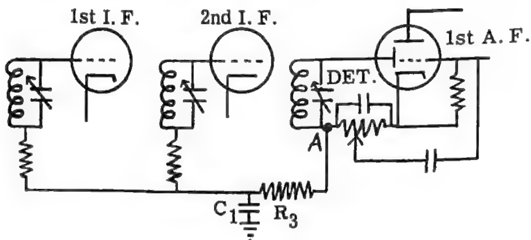
Q. 211. If the two towers of a 950-kilocycle directional antenna are separated by 120 electrical degrees, what is the tower separation in feet?

A. 345.28 feet.
First we convert frequency into wavelength

$$\text{wavelength in meters} = \frac{300,000}{\text{f. in kc.}} = \frac{300,000}{950} = 315.8 \text{ meters}$$

Since 360° is a complete wavelength, 120° is a third of a wavelength. The separation of the 2 towers is therefore $315.8 \div 3 = 105.27$ meters. We multiply meters by 3.28 to obtain feet. The distance in feet is therefore $105.27 \times 3.28 = 345.28$ feet.

Q. 212. Draw a diagram showing how automatic volume control is accomplished in a standard broadcast receiver.



A212 Automatic volume control circuit

Q. 213. What is the required full scale accuracy of the plate ammeter and plate voltmeter of the final radio stage of a standard broadcast transmitter?

A. 2 percent

Q. 214. What is the maximum carrier shift permissible at a standard broadcast station?

A. Plus or minus 20 cycles.

Q. 215. In accordance with the Commission's Standards of Good Engineering Practice, what determines the maximum permissible full scale reading of indicating instruments required in the last radio stage of a standard broadcast transmitter?

A. The maximum full scale reading shall not be greater than 5 times the minimum normal indication.

Q. 216. When an X- or a Y-cut crystal is employed in the automatic frequency control equipment at a standard broadcast station, what is the maximum permitted temperature variation at the crystal from the normal operating temperature? (S.G.E.P. -A.M. 12.)

A. The maximum temperature variation at the crystal from the normal operating temperature shall not be greater than plus or minus 0.1°C. when an X or Y cut crystal is employed.

Q. 217. What is the purpose of a discriminator in an f-m broadcast receiver?

A. The discriminator of an f-m receiver is similar in function to the detector of an a-m receiver. It extracts the audio from the frequency variations of the carrier.

Q. 218. Explain why high gain antennas are used at f-m broadcast stations.

A. High gain antennas for f-m broadcast stations are used because the useful radiated ground wave is rapidly attenuated as it leaves the antenna. Since the skywaves at the f-m broadcast frequencies travel to outer space and never return, we are primarily interested in the ground wave which travels in a horizontal plane. Since high gain antennas are highly directional, we use them to direct the radiated wave in a horizontal plane.

Q. 219. What is the frequency swing of an FM broadcast transmitter when modulated 60 percent?

A. The frequency swing of an f-m broadcast transmitter, when modulated 60% is plus or minus 45kc. This is 60% of ± 75 kc., which is the frequency swing for 100% modulation of an f-m broadcast station.

Q. 220. An f-m broadcast transmitter is modulated 50 percent by a 7,000-cycle test tone. When the frequency of the test tone is changed to 5,000 cycles and the percentage of modulation is unchanged, what is the transmitter frequency swing?

A. The frequency swing is ± 37.5 kc. This is 50% of ± 75 kc. The frequency of the modulating signal has nothing to do with the frequency swing of the carrier.

Q. 221. What is a common method of obtaining frequency modula-

tion in an f-m broadcast transmitter?

A. There are several methods. One is the reactance tube method in which a tube and its circuit is made to act as an inductance or a capacitance. We place the reactance tube circuit across the tank circuit of a master oscillator. We then feed the audio to the grid of the reactance tube. The audio variations cause the "acting" inductance or capacitance to vary and this, in turn, causes the oscillator's frequency to vary.

Another method is the Armstrong phase-shift system which uses balanced modulators.

Q. 222. What is meant by pre-emphasis in an f-m broadcast transmitter?

A. Pre-emphasis at the transmitter is the additional amplification of the higher audio frequencies compared to the lower audio frequencies.

Most noise and interference produce signals at the higher audio frequencies. At the receiver, we receive the desired signal with its emphasized high frequencies together with the higher frequency noise signals. We use a de-emphasis circuit in the receiver which reduces the higher audio frequencies. This attenuates the noise as well as a part of the desired signal. However, the higher frequencies of the desired audio signal were overamplified to start with (pre-emphasis); so we are merely reducing these back to normal. The overall result of this system is the reduction of noise.

Q. 223. What is the purpose of a de-emphasis circuit in an f-m broadcast receiver?

A. See answer 222.

Q. 224. An f-m broadcast transmitter operating on 98.1 megacycles has a reactance tube-modulated oscillator operating on a frequency of 4905 kilocycles. What is the oscillator frequency swing when the transmitter is modulated 100 percent by a 2,500-cycle tone?

A. ± 3.75 kc. At 100% modulation the outgoing frequency of the signal is 98.1 Mc. ± 75kc. If we divide 98.1 Mc. by 4905kc. we know how many times the oscillator frequency has been multiplied. 98.1 Mc. ÷ 4.905 Mc. = 20. If we divide the ± 75 kc, swing by 20, we have the original frequency swing of the oscillator. ± 75 kc. ÷ 20 = ± 3.75 kc.

Q. 225. What characteristic of an audio tone determines the percentage of modulation of an f-m broadcast transmitter?

A. The amplitude of the audio determines the percentage of modulation in an f-m transmitter.

Q. 226. What determines the rate of frequency swing of an f-m broadcast transmitter?

A. The frequency of the audio determines the rate of frequency swing in an f-m transmitter.

Q. 227. How wide a frequency band must the intermediate frequency amplifier of an f-m broadcast receiver pass?

A. The i-f amplifier of an f-m broadcast receiver should pass a frequency band of 150 kc. since the f-m signal can vary 75 kc. on either side of the center frequency.

Q. 228. An f-m broadcast transmitter is modulated 40 percent by a 5,000-cycle test tone. When the percentage of modulation is doubled, what is the frequency swing of the transmitter?

A. ± 60 kc. Doubling 40% gives us 80% and 80% of ± 75 kc. is ± 60 kc.

Q. 229. If an f-m transmitter employs one doubler, one tripler and one quadrupler, what is the carrier frequency swing when the oscillator frequency swing is 2 kilocycles?

A. The carrier frequency swing is 48 kc. We arrive at this answer by multiplying 2 kc. by the amount of multiplication of each amplifier. 2 kc. x 2 x 3 x 4 = 48 kc.

Q. 230. What is the purpose of a "reactance tube" in an f-m broadcast transmitter?

A. See answer 221.

Q. 231. What is a ratio detector?

A. A ratio detector is a form of detector used in an f-m receiver. A ratio detector does not require a limiter stage to clip the amplitude variations as does the discriminator type of f-m detector. A ratio detector acts as a detector and limiter (clips or cuts amplitude variations) in one stage.

Q. 232. How does the amount of audio power required to modulate a 1,000-watt f-m broadcast transmitter compare with the amount of audio power required to modulate a 1,000-watt standard braodcast transmitter to the same percentage of modulation?

A. The power required to modulate an f-m transmitter is extremely small compared to the power required to modulate an a-m transmitter.

Q. 233. What is the purpose of a limiter stage in an f-m broadcast receiver?

A. A limiter stage clips or cuts the amplitude variations in the f-m signal. The amplitude variations represent interference or noise and is removed by the limiter before the signal gets into the f-m detector.

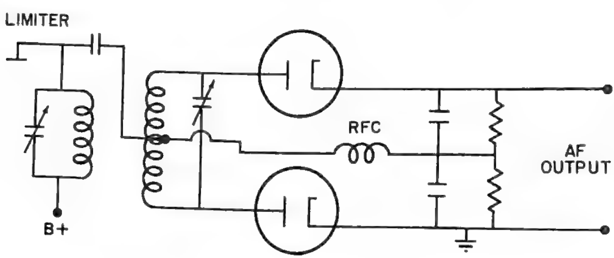
Q. 234. If the transmission line current of an f-m broadcast transmitter is 8.5 amperes without modulation, what is the transmission line current when the percentage of modulation is 90 percent?

A. It is still 8.5 amperes. During modulation, the frequency is varied, not the transmission line current.

Q. 235. An f-m broadcast transmitter has 370 watts plate power input to the last radio-frequency stage and an antenna field gain of 1.3. The efficiency of the last radio-frequency stage is 65 percent and the efficiency of the antenna transmission line is 75 percent. What is the effective radiated power?

A. The effective radiated power is 304.834 watts. First we find the output power of the last r-f stage. $370 \times .65 = 240.5$ watts. We then find the output of the transmission line. $240.5 \times .75 = 180.375$ watts. We multiply this by $(1.3)^2$ to find the effective radiated power $180.375 \times 1.69 = 304.834$ watts. We square the 1.3 because antenna gain is given in terms of voltage and we are calculating power. The power is proportional to the square of the voltage.

Q. 236. Draw a diagram of an FM broadcast receiver detector circuit.



A 236 A discriminator type of f-m detector

Q. 237. Draw a diagram of a means of modulation of an f-m broadcast station.

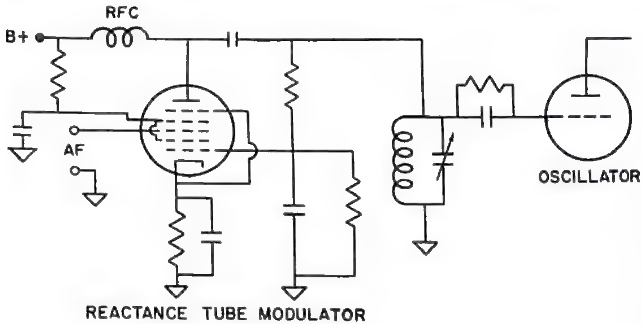
Q. 238. Draw a diagram of a limiter stage in an f-m broadcast receiver.

Q. 239. How is the operating power of an f-m broadcast station determined?

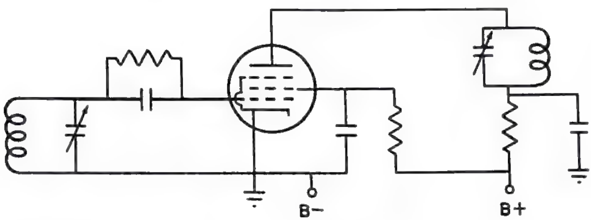
A. The operating power of each station shall be determined by the indirect method. This is the product of the plate voltage (E_p) and the plate current (I_p) of the last radio stage, and an efficiency factor, F; that is:

$$\text{Operating power} = E_p \times I_p \times F$$

The efficiency factor, F, shall be established by the transmitter



A237 A reactance tube modulator



A238 A limiter stage. Note: Plate and screen voltages are low (60 to 90 volts).

manufacturer for each type of transmitter for which Commission approval is requested.

Q. 240. If an f-m broadcast station uses a total of 5 tubes of a given type at the transmitter, what is the minimum number of spare tubes of this type required at the transmitter?

A. A minimum of 2 spare tubes is required. See answer 153.

Q. 241. What is the required frequency range of the indicating device on the frequency monitor at an f-m broadcast station?

A. The frequency range of the indicating device on the frequency monitor at an f-m broadcast station must be at least 2,000 cycles on either side of the assigned center frequency.

Q. 242. What is the audio frequency range that an f-m broadcast station is required to be capable of transmitting? (R. & R. 3.254.)

A. 50 to 15,000 cycles per second.

Q. 243. How wide is an f-m broadcast channel? (S.G.E.P.-F.M. 1.)

A. The total bandwidth is 200 kc.

Q. 244. What frequency swing is defined as 100 percent modulation for an f-m broadcast station? (S.G.E.P.-F.M. 1.)

A. Plus or minus 75 kc.

Q. 245. What is the tolerance in operating power of f-m broadcast stations? (R. & R. 3.267.)

A. The allowable tolerance of the f-m station is 5% above and 10% below the authorized power.

Q. 246. What is the meaning of the term "Center Frequency" in reference to f-m broadcasting? (S.G.E.P.-F.M. 1.)

A. The term "center frequency" means:

1. The average frequency of the emitted wave when modulated by a sinusoidal signal or,
2. The frequency of the emitted wave without modulation.

Q. 247. Exclusive of monitors, what indicating instruments are required in the transmitting system at an f-m broadcast station? (R. & R. 3.258.)

A. Each f-m broadcast station shall be equipped with indicating instruments for measuring the direct plate voltage and current of the

last radio stage and the transmission line radio frequency current, voltage or power.

Q. 248. What is the required accuracy of instruments indicating the plate current and the plate voltage of the last radio stage or the transmission line current or voltage at an f-m broadcast station? (S.G.E.P.-F.M. 9.)

A. Their accuracy shall be at 2% of the full scale reading.

Q. 249. What is the frequency tolerance of an f-m broadcast station? (R. & R. 3.269.)

A. The center frequency of each f-m broadcast station shall be maintained within 2000 cycles of the assigned center frequency.

Q. 250. What is the meaning of the term "frequency swing" in reference to f-m broadcast stations? (S.G.E.P.-F.M. 1.)

A. The term "frequency swing" means the instantaneous departure of the frequency of the emitted wave from the center frequency resulting from modulation.

Q. 251. Why is a scanning technique known as "interlacing" used in television broadcasting?

A. See answer 255.

Q. 252. Does the video transmitter at a television broadcast station employ frequency or amplitude modulation?

A. Amplitude modulation.

Q. 253. Does the sound transmitter at a television broadcast station employ frequency or amplitude modulation?

A. Frequency modulation.

Q. 254. What is a monitor picture tube at a television broadcast station?

A. A monitor picture tube is an actual picture tube on which the picture being broadcast is shown. Monitors may be placed at different points in the television transmitting system to monitor the picture at the various points. The monitors permit the operators to determine any faults in the picture.

Q. 255. Describe scanning as used by television broadcast stations. Describe the manner in which the scanning beam moves across the picture in the receiver.

A. Scanning is the process of subdividing a picture into tiny areas so that information can be transmitted in an orderly manner. Each bit of picture information is sent out one bit at a time. The bits of information are then reassembled in the correct manner at the receiver to form a complete picture.

At the transmitter, a camera tube is used to convert the picture information into electrical information. One of the basic camera tubes is the ICONOSCOPE. In the iconoscope, the scene to be televised is focused by an optical lens system onto a mosaic plate. The mosaic plate consists of a thin sheet of mica on the front of which has been deposited a layer of microscopic globules of cesium-silver. These globules are photo-sensitive and give off electrons in proportion to the light striking them. Each globule tends to dissociate itself from the other globules so that each globule is insulated from its neighbor. Electrically, any change that affects one globule will not affect the others. Behind the mica sheet is a coating of colloidal graphite. This acts as a signal plate.

An electron beam from the electron gun in the neck of the iconoscope tube is forced by deflection coils to sweep across the mosaic plate in a series of lines. As the beam passes over each globule, it replaces the electrons lost due to the light rays. By condenser action, this effect is felt by the colloidal graphite signal plate and these electrical variations constitute the picture signal. The picture is actually broken up into 525 horizontal lines and the beam scans the picture one line at a time. The 525 lines are transmitted 30 times per second. In practice, we scan the 262-1/2 odd lines first. Then we scan the 262-1/2 even lines. In doing this, we make it appear to the eye that 60 pictures per second are being sent out (60 x 262-1/2 lines). This is known as "interlaced scanning" and the system is used because it eliminates "flicker". If the eye sees 30 pictures per second, the action does not appear to be continuous. However, if we scan every other line and send out 60 "pictures" per second, the flicker effect will disappear and the action will appear to be continuous.

In the receiver picture tube, the beam scans the face of the picture tube in the same manner as in the transmitter camera tube and converts the electrical variations back into light and dark areas or picture variations.

Q. 256. What is a mosaic plate in a television camera?

A. See above answer (255).

Q. 257. What is the purpose of synchronizing pulses in a television broadcast signal?

A. The synchronizing pulses are used to synchronize the beam movement in the receiver with that in the transmitter. In other words

when the beam in the transmitter is sending out the first line of picture information, we must make sure that the beam in the receiver is moving across the first line; when the transmitter beam is moving from the bottom of the picture up to the top to start a new picture, the receiving tube's beam must be doing the same thing, etc.

Q. 258. What is the effective radiated power of a television broadcast station if the output of the transmitter is 1,000 watts, antenna transmission line loss is 50 watts and the antenna power gain is 3? (R. & R. 3.681.)

A. The effective radiated power is 2850 watts. The power going to the antenna is 950 watts (1000 watts minus 50 watts lost in transmission line). If the antenna power gain is 3, we multiply by 3 to get the effective radiated power. 950 x 3 = 2850.

Q. 259. Besides the camera signal, what other signals and pulses are included in a complete television broadcast signal?

A. Besides the camera signal, the following signals and pulses are included in the complete television broadcast signal:

1. the f-m sound signal
2. the horizontal synchronizing pulses
3. the vertical synchronizing pulses
4. the horizontal blanking pulses
5. the vertical blanking pulses
6. the equalizing pulses

Q. 260. What are synchronizing pulses in a television broadcasting and receiving system?

A. The synchronizing pulses are short rectangular pulses that are sent out by the transmitter to control the timing of the beam in the receiver picture tube. These pulses make certain that the beam starts on time for each line and each picture.

Q. 261. What are blanking pulses in a television broadcasting and receiving system?

A. Blanking pulses are used to blank out the beam when it is moving from right to left to start a new line and from bottom to top to start a new picture.

Q. 262. For what purpose is a voltage of sawtooth wave form used in a television broadcast receiver?

A. The sawtooth wave is produced in the deflection circuits of the receiver to produce the proper horizontal and vertical movements of the beam.

Q. 263. In television broadcasting, what is the meaning of the term "aspect ratio"? (R. & R. 3.681.)

A. The aspect ratio is the ratio of the picture width to picture height.

Q. 264. How many frames per second do television broadcast stations transmit?

A. A television station transmits 30 frames per second. (A frame consists of 525 lines.)

Q. 265. In television broadcasting, why is the field frequency made equal to the frequency of the commercial power supply?

A. This is done in order to prevent the power supply ripple from causing dark areas to move up and down the picture. If the ripple frequency and the field frequency are the same, the slight ripple that does appear in the picture will not move and therefore will not be noticeable.

Q. 266. If the cathode ray tube in a television receiver is replaced by a larger tube such that the size of the picture is changed from 8 by 6 inches to 16 by 12 inches, what change if any is made in the number of scanning lines per frame?

A. No change in scanning lines per frame is made.

Q. 267. If a television broadcast station transmits the video signals in channel No. 6 (82 to 88 Mc), what is the center frequency of the aural transmitter? (R. & R. 3.682.)

A. The center frequency of the aural transmitter is 87.75 Mc. The FCC standards call for the aural center frequency to be .25 Mc below the upper limit of the channel.

Q. 268. What is the field frequency of a television broadcast transmitter?

A. The field frequency is the number of times per second that the picture is scanned. It is the number of pictures per second that the eye "appears to see". The FCC standards call for a field frequency of 60 per second. In the system of interlaced scanning, every other line is scanned in a field.

Q. 269. How is the operating power of the aural transmitter of a television broadcast station determined? (R. & R. 3.689.)

A. It is determined by the indirect method as follows:

$$P = E_p \times I_p \times F$$

where: E_p and I_p are plate voltage and plate current of the last stage

F is the efficiency factor as specified by the manufacturer of the transmitter.

Q. 270. Numerically, what is the aspect ratio of a picture as transmitter by a television broadcast station? (R. & R. 3.681.)

A. It is 4 wide to 3 high.

Q. 271. What is meant by vestigial side band transmission of a television broadcast station? (R. & R. 3.681.)

A. Vestigial sideband transmission is a system of transmission wherein one of the generated sidebands is partially attenuated at the transmitter and radiated only in part.

Q. 272. What is the frequency tolerance for television broadcast transmitters? (R. & R. 3.687.)

A. The frequency tolerance for the visual transmitter is ±1 kc. For the aural transmitter it is ±4 kc.

Q. 273. What is meant by antenna field gain of a television broadcast antenna?

A. The antenna field gain of a particular antenna is the ratio of the free space field intensity produced at one mile in the horizontal plane, in millivolts per meter to the field intensity produced at one mile in a horizontal plane when a simple dipole antenna is used.

Q. 274. How wide is a television broadcast channel? (R. & R. 3.682.)

A. The television channel width is 6 Mc.

Q. 275. If standard broadcast emissions are classified as A3 emission, what is the classification of television broadcast video emissions? (R. & R. 2.201.)

A. Television broadcast video emissions are classified as A5.

Q. 276. What is the range of audio frequencies that the aural transmitter of a television broadcast station is required to be capable of transmitting? (R. & R. 3.687.)

A. 50 to 15,000 cycles per second.

Q. 277. What is meant by one hundred percent modulation of the aural transmitter at a television broadcast station? (R. & R. 3.687.)

A. We have 100% modulation when the frequency swing is ±25 kc.

Q. 278. What is the frequency tolerance for a broadcast STL station? (R. & R. 4.561.)

A. Plus or minus .005 percent of the assigned frequency.

Q. 279. What are the radio operator license requirements for the person on duty at an experimental television broadcast station? (R. & R. 4.166.)

A. One or more radio operators holding radiotelephone first-class or radiotelephone second-class operator licenses shall be on duty at the place where the transmitting apparatus of an experimental television broadcast station is located and in actual charge of its operation. The licensed operator on duty and in charge of a broadcast transmitter may at the discretion of the licensee be employed for other duties or for the operation of another station or stations in accordance with the class of operator's license which he holds and the rules and regulations governing such stations.

Q. 280. What type of antenna is required at a broadcast STL station? (R. & R. 4.536.)

A. Each broadcast STL station is required to employ a directional antenna. Considering one kilowatt of radiated power as a standard for comparative purposes, such antenna shall provide a free space field intensity at one mile of not less than 435 mv/m in the main lobe of radiation toward the receiver and not more than 20 percent of the maximum value in any azimuth 30° or more off the line to the receiver.

Q. 281. What is the frequency tolerance for a noncommercial educational FM broadcast station? (R. & R. 3.569.)

A. The center frequency of each noncommercial educational FM broadcast station licensed for transmitter power output of 10 watts or less shall be maintained within 3,000 cycles of the assigned center frequency. The center frequency of each noncommercial educational FM broadcast station licensed for transmitter power output above 10 watts shall be maintained within 2,000 cycles of the assigned center frequency.

Q. 282. What are the licensed operator requirements for a TV broadcast station? An FM broadcast station? A 5-kw. night-time directional standard broadcast station? (R. & R. 3.165, 3.265, 3.661.)

A. In all the above types of stations, one or more first class operators must be on duty at the place where the transmitting apparatus

of each station is located and in actual charge whenever it is being operated.

The licensee of a station which is operated by one or more operators holding other than a radiotelephone first class operator license shall have one or more operators holding a first class operator license in regular full time employment at the station.

Q. 283. Under what conditions may a standard broadcast station be operated by remote control? (R. & R. 3.66.)

A. A station which is authorized for non-directional operation with power of 10 kilowatts or less may, upon prior authorization from the Commission, be operated by remote control at the point(s) which shall be specified in the station license. An application for authorization to operate by remote control may be made as a part of an application for construction permit or license, or modification thereof by specifiying the proposed remote control point(s). Operation by remote control shall be subject to the following conditions:

a. The equipment at the operating and transmitting positions shall be so installed and protected that it is not accessible to or capable of operation by persons other than those duly authorized by the licensee.
b. The control circuits from the operating position to the transmitter shall provide positive on and off control and shall be such that open circuits, short circuits, grounds or other line faults will not actuate the transmitter and any fault causing loss of such control will automatically place the transmitter in an inoperative condition.
c. Control and monitoring equipment shall be installed so as to allow the licensed operator either at the remote control point or at the transmitter, to perform all of the functions in a manner required by the Commission's rules and Standards.

Q. 284. Within what limits is the operating power of a TV aural or visual transmitter required to be maintained? (R. & R. 3.689.)

A. The operating power of the aural transmitter and the visual transmitter shall be maintained as near as practicable to the authorized operating power, and shall not exceed the limits of 10% above and 20% below the authorized power except in emergencies.

Q. 285. Describe the composition of the Chrominance subcarrier used in the authorized system of color television.

A. The chrominance subcarrier is the carrier which is modulated by chrominance information, chrominance being the colorimetric difference between any color and a reference color of equal brightness. The chrominance subcarrier has a frequency of 3.58 Mc.

Q. 286. Describe the procedure and adjustments necessary to couple properly a typical VHF visual transmitter to its load circuits.

A. There are various procedures for coupling a visual transmitter to its load circuits. These depend on the individual transmitter and are given in the instruction manual that accompanies the transmitter.

We will concern ourselves with the model TT-50AH. This is an RCA television broadcast transmitter intended for channels 7 to 13. The stage preceding the power amplifier is grid modulated.

Tuning of the visual transmitter is performed in 2 steps. First the output of the modulated-amplifier is coupled to a test load and the visual section tuned up to and including the modulated-amplifier. The second step in visual tuning is to couple the modulated-amplifier to the power amplifier and then tune the combination for optimum performance. Slight readjustment of the modulated-amplifier output circuit will be required when the power amplifier is substituted for the test load, but this change will be slight because the power amplifier grid circuit is very broad.

Some of the important steps in the actual tuning of the visual transmitter are as follows:

1. Adjust the transformer secondary tap settings for the required power output.
2. Adjust the following controls and switches in the visual modulator section for the correct voltages and currents (as given in the instruction manual):
   a. the black level control
   b. the total modulator current control
   c. the amplifier coupling switch
   d. the video gain control
3. Tune up the visual exciter stages
4. Connect an 80 watt r-f load and wattmeter to the output of the driver tube. Adjust the plate tuning of the visual driver stage for a dip on its plate current meter. Tune the following controls for maximum driver grid current as read on the driver grid current meter:
   a. the output tuning and output coupling controls of the stage preceding the driver
   b. the driver input tuning
   c. the driver input coupling
5. Neutralize the driver
6. Tune up the modulated amplifier stage, using the 80 watt r-f load and wattmeter connected to its output. During this step, the modulated amplifier grid tuning control should be adjusted for minimum reflected power on the r-f excitation meter.
7. Neutralize the modulated amplifier stage

8. Tune up the visual power amplifier stage (consisting of five 6166 tubes in parallel) in the following manner:
   a. increase excitation slowly until the total plate current is approximately 6 amperes.
   b. using the input coupling and input tuning controls, tune the input circuit for minimum standing wave ratio as indicated on the driver reflectometer.
   c. using the plate tuning and output tuning controls, adjust the amplifier plate circuit for maximum power output consistant with bandwidth, as indicated by the sideband response analyzer.

Q. 287. Draw a block diagram of a typical monochrome television transmitter indicating the function of each part.

Q. 288. Describe the scanning process employed in connection with color TV broadcast transmission.

A. The scanning process employed in color TV is similar to the scanning process employed in black and white TV. See question 255 for a discussion of the scanning process. The only difference between the two scanning systems is that their horizontal and vertical scanning frequencies are slightly different. The black and white horizontal and vertical frequencies are 15,750 cycles and 60 cycles respectively whereas the color horizontal and vertical frequencies are 15,734 cycles and 59.94 cycles respectively.

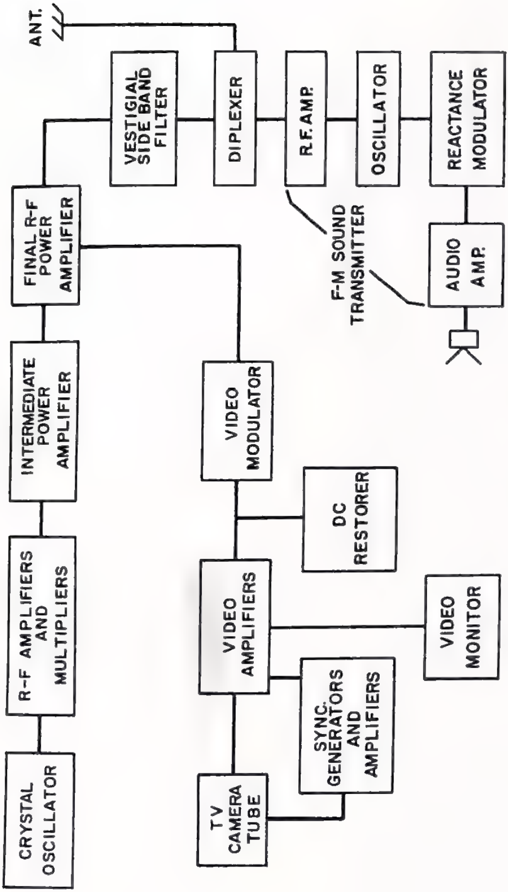
Q. 289. Under what conditions should the indicating instruments of a TV visual transmitter be read in order to determine operating power.

Q. The operating power of the visual transmitter shall be determined at the output terminal of the vestigial sideband filter, if such filter is used; otherwise, at the transmitter output terminal. The average power shall be measured while operating into a dummy load of substantially zero reactance and a resistance equal to the transmission line surge impedance, while transmitting a standard black television picture.

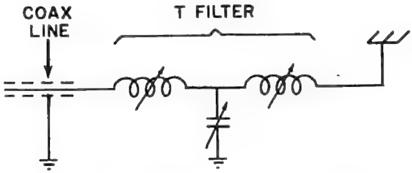
Q. 290. In a transmitted monochrome television signal what is the relationship between peak carrier level and the blanking level? (R. & R. 3.682.)

A. The blanking level is 75 ±2.5% of the peak carrier level.

Q. 291. Draw a simple schematic diagram of a T-type coupling network suitable for coupling a coaxial line to a standard broadcast antenna. Include means for harmonic attenuation.



A287 A block diagram of a typical television transmitter



A291 A T-type coupling network for coupling a coaxial line to an antenna

FCC-TYPE EXAMINATION

ELEMENT 4

1. A type of voltmeter that absorbs no power from the circuit under test is a:
   a. hot wire meter
   b. vacuum tube voltmeter
   c. thermocouple meter
   d. high frequency ammeter

2. A class C amplifier has:
   a. high efficiency
   b. low efficiency
   c. excellent regulation
   d. excellent fidelity

3. In high level modulation the audio is added to the carrier:
   a. in the oscillator stage
   b. in the buffer stage
   c. in the final amplifier stage
   d. through a phase shift network

4. The first step in neutralizing an r-f amplifier is to:
   a. remove the plate voltage
   b. tune the plate circuit to resonance
   c. Adjust the neutralizing condenser for minimum output on the r-f indicator
   d. tune the grid circuit to resonance

5. A T or H pad attenuator provides, in addition to attenuation:
   a. equalization
   b. neutralization
   c. impedance matching
   d. none of the above

6. D-c core saturation of an audio transformer working out of a single tube can be reduced by:
   a. isolating d-c from the primary of the transformer
   b. using a smaller core
   c. placing a choke in series with the plate lead going to the primary of the transformer
   d. using a triode audio amplifier tube

7. Loading a tuned circuit with a resistance will:
   a. sharpen the frequency response
   b. increase the Q of the tuned circuit
   c. increase the possibility of undesired oscillation
   d. reduce the Q of the tuned circuit

8. If a broadcast transmitter uses 5 tubes of a particular type, it must keep:
   a. one spare on hand
   b. two spares on hand
   c. three spares on hand
   d. four spares on hand

9. If an alternating current of 2 amperes flows in a series circuit consisting of 3 ohms of resistance, 14 ohms of inductive reactance, and 10 ohms of capacitive reactance, what is the voltage across the circuit?
   a. 6V.
   b. 54V.
   C. 10V.
   d. 14V.

10. Crystals are sometimes operated in temperature controlled ovens in order to:
   a. increase frequency drift
   b. increase frequency stability
   c. eliminate the need for neutralization
   d. minimize parasitic oscillations

11. The ratio of resistance to impedance in an a-c circuit is called:
   a. power factor
   b. Q
   c. apparant power
   d. skin effect

12. The width of the complete broadcast television channel is:
   a. 1.25 Mc.
   b. 4.5 Mc.
   c. 4.75 Mc.
   d. 6 Mc.

13. The condition in television broadcasting, where the upper video sideband and a part of the lower video sideband are transmitted, is called:
   a. single side band transmission
   b. vestigial side band transmission
   c. centrifugal side band transmission
   d. high level transmission

14. The aspect ratio of the picture that is transmitted by a television broadcast transmitter is:
   a. 5 to 4
   b. 4 to 5
   c. 4 to 3
   d. 3 to 2

15. In order to prevent hum bars from moving across the screen, the basic design of the television system calls for:
   a. the television transmitter using very large filter condensers
   b. the use of a pre-emphasis circuit in the transmitter and a de-emphasis circuit in the receiver.
   c. interlaced scanning
   d. the field frequency being equal to the commercial power supply frequency.

16. If a frequency doupler stage has an input frequency of 2 Mc. and the plate inductance is 40 microhenries, what value of plate capacitance is necessary for resonance, neglecting stray capacitances?
    a. 420 mmfd. b. 62.3 mmfd. c. 39.5 mmfd. d. 23.4 mmfd.

17. Which of the following should not be done to insure good frequency stability of a crystal controlled oscillator?
    a. use a well regulated power supply
    b. use a constant temperature compensated oven
    c. use a buffer stage between the oscillator and the final stage
    d. maintain a large amount of feedback to the crystal.

18. What is the percentage of regulation of a power supply having a no load voltage of 150 volts and a full load voltage of 130 volts?
    a. 15.4% b. 20% c. 13.3% d. 120%

19. A circuit that passes all frequencies above a certain frequency is called a:
    a. high pass filter
    b. low pass filter
    c. a high level attenuator
    d. a low level attenuator

20. Overmodulation does not result in:
    a. distortion
    b. spurious harmonic radiation
    c. interference to adjacent frequencies
    d. parasitic oscillation

21. What is the height of a vertical radiator 1/2 wavelength high if the operating frequency is 2000 kc.
    a. 75 meters b. 150 meters c. 37.5 meters d. 300 meters

22. Terminating a transmission line in an impedance equal to the characteristic impedance of the line prevents:
    a. standing waves
    b. distortion
    c. overmodulation
    d. downward modulation

23. What is the current flowing in a 72 ohm concentric line if the power input to it is 2 kilowatts?
    a. 1.44 amperes
    b. 3.6 amperes
    c. 5.26 amperes
    d. 2.77 amperes

24. Positive carrier shift in a modulated class C r-f amplifier is not caused by:

a. excessive audio
b. improper neutralization
c. insufficient audio drive
d. improper tuning

25. Our standard broadcast band could not accomodate f-m stations because:
    a. it is impossible to frequency modulate a carrier in the broadcast band
    b. f-m stations occupy a large amount of frequency space
    c. large amounts of power are required in the broadcast band
    d. the noise level in the broadcast band would be too high for f-m reception

26. A class B modulator does not:
    a. have greater efficiency than a class A modulator
    b. require less drive than a class A modulator
    c. require 2 tubes in push-pull circuits
    d. require a well regulated power supply

27. During 100% sinusoidal modulation the percentage of average total output power in the sidebands is:
    a. 25%
    b. 30%
    c. 33%
    d. 50%

28. A carbon microphone has:
    a. excellent frequency response
    b. a high output
    c. a low noise level
    d. a high impedance

29. Which of the following microphones has a coil of wire that moves in a magnetic field?
    a. a ribbon microphone
    b. a velocity microphone
    c. a condenser microphone
    d. a dynamic microphone

30. A line equalizer is used to:
    a. increase the frequency response of a transmission line
    b. match the impedance of the microphone to the transmission line
    c. flatten the frequency response of the transmission line
    d. match the impedance of the transmission line to the transmitter

31. In order to improve the fidelity of an amplifier, we sometimes introduce:
    a. an H pad attenuator
    b. a T pad attenuator
    c. a neutralizing condenser
    d. degenerative feedback

32. The ratio of impedances that a transformer can match is determined chiefly by its:

a. iron and copper losses
b. type of winding used
c. current carrying capacity
d. turns ratio

33. The frequency tolerance of the video carrier of a television broadcast transmitter is:
a. ± .01 kc. b. ± .05 kc. c. ± .1 kc. d. ± 1 kc.

34. The synchronizing pulses in a television receiver are fed to the:
a. high voltage stage
b. vertical and horizontal oscillator stages
c. damping stage
d. a.v.c. circuit

35. A blanking pulse is used to:
a. trigger the vertical oscillator
b. erase the beam while it is being brought back to the left side of the picture
c. blank out the vertical oscillator while the horizontal oscillator is operating and vice versa
d. trigger the horizontal oscillator during retrace periods

36. A type of f-m detector that does not require a limiter is the:
a. ratio detector
b. Foster-Seeley detector
c. Armstrong detector
d. impedance detector

37. The stage that reduces amplitude modulation in an f-m receiver is the:
a. limiter stage
b. discriminator stage
c. oscillator stage
d. i-f stage

38. What arrangement of multiplier stages is necessary to bring an oscillator frequency swing of 3 kc. up to an output carrier swing of 54 kc?
a. 2 doublers and a tripler
b. a tripler and a quadrupler
c. a doubler and 2 triplers
d. a doubler, a tripler and a quadrupler

39. If a 500 kc. X-cut crystal is calibrated at 40 degrees centigrade and it has a temperature coefficient of -15 cycles per megacycle per degree centigrade, at what frequency will it oscillate when its temperature is 50 degrees centigrade?
a. 500.75 kc. b. 500.150 kc. c. 499.925 kc. d. 499.725 kc.

40. The required full scale accuracy in ammeters and voltmeters associated with the final stage of a broadcast transmitter is:
a. 1% b. 2% c. 5% d. .5%

41. The indirect method of measuring the operating power of a transmitter:
    a. makes use of the antenna current and the antenna resistance
    b. is equal to the product of the plate voltage and plate current of the last stage
    c. uses a factor, F, that depends on the type of modulation used
    d. can always be used to measure the power of a transmitter

42. A remote-reading ammeter must be checked against a regular antenna ammeter at least:
    a. once a day
    b. once a week
    c. once a month
    d. before and after each transmission

43. The percentage of modulation capability required of a standard broadcast station is:
    a. 75% b. 80% c. 85% d. 100%

44. If the mutual inductance between 2 coils is .4 henry and the coils have inductances of .8 henry and 2 henries, what is the coefficient of coupling?
    a. .25 b. 1.6 c. .32 d. .4

45. If a transformer with a 95% efficiency has a primary voltage of 110 volts and a secondary of 1650 volts, what is the primary current when the secondary current is 100 ma.?
    a. 1.5A. b. 1.65A. c. 1.73A. d. 1.58A.

46. Draw a simple schematic diagram of a multivibrator oscillator.

47. Draw a diagram of a voltage doubling power supply using 2 half wave rectifiers.

48. Draw a diagram of an f-m broadcast receiver detector circuit.

49. Draw a diagram of a grounded-grid amplifier.

50. Draw a simple schematic diagram of a class B audio high-level modulation system, including the modulated r-f stage.

ANSWERS TO
FCC-TYPE EXAMINATION
ELEMENT 4

1 b	11 a	21 a	31 d	41 c
2 a	12 d	22 a	32 d	42 b
3 c	13 b	23 c	33 d	43 c
4 a	14 c	24 c	34 b	44 c
5 c	15 d	25 b	35 b	45 d
6 a	16 c	26 b	36 a	46 see answer 104
7 d	17 d	27 c	37 a	47 see answer 178
8 b	18 a	28 b	38 c	48 see answer 236
9 c	19 a	29 d	39 c	49 see answer 189
10 b	20 d	30 c	40 b	50 see answer 41

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